THIRTEENTH EDITION

Grant's DISSECTOR

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FIGURE CREDITS

CHAPTER 1

Modified from Agur A. *Grant's Atlas of Anatomy*, 9E. Baltimore: Lippincott Williams & Wilkins, 1991. Figures 1.05, 1.06.

From Basmajiam: *Grant's Method of Anatomy*, 11E, 1989. Figure 1.10.

Modified from Woodburne: *Essentials of Human Anatomy*, 9E, Oxford University Press,1994, Figure 1.16.

CHAPTER 2

Modified from Netter F. *Netter's Atlas of Human Anatomy*, 3E. Carlstadt, NJ: Icon Learning System, 2002. Figures 2.05, 2.12, 2.27, 2.28, 2.31, 2.32.

CHAPTER 3

Modified from Clemente CD. *Anatomy Dissector*. Baltimore: Lippincott Williams & Wilkins, 2002. Figure 3.17.

Modified from Moore K, Dalley AF. *Clinically Oriented Anatomy*, 4E. Baltimore: Lippincott Williams & Wilkins, 1999. Figures 3.06, 3.07.

Modified from Netter F. *Netter's Atlas of Human Anatomy*, 3E. Carlstadt, NJ: Icon Learning System, 2002, Figures 3.24 and 3.25B.

Modified from Woodburne. *Essentials of Human Anatomy*, 9E, Oxford University Press, 1994. Figure 3.01.

CHAPTER 4

Modified from Agur A, Dalley AF. *Grant's Atlas of Anatomy*, 11E, Baltimore: Lippincott Williams & Wilkins, 2005. Figures 4.20, 4.46, 4.47, 4.53.

Modified from Moore K, Agur A. *Essential Clinical Anatomy*, 2E. Baltimore: Lippincott Williams & Wilkins, 2002. Figure 4.11.

Modified from Moore K, Dalley AF. *Clinically Oriented Anatomy*, 4E. Baltimore: Lippincott Williams & Wilkins, 1999, page 199, Figures 4.16, 4.18, 4.25, 4.48.

Modified from Netter F. *Netter's Atlas of Human Anatomy*, 3E. Carlstadt, NJ: Icon Learning System, 2002. Figures 4.06, 4.09, 4.10, 4.12, 4.19.

CHAPTER 5

Modified from Agur A. *Grant's Atlas of Anatomy*, 9E. Baltimore: Lippincott Williams & Wilkins, 1991. Figures 5.08, 5.18, 5.19, 5.24, 5.33, 5.34.

Modified from Clemente CD. *Anatomy Dissector*. Baltimore: Lippincott Williams & Wilkins, 2002. Figures 5.03, 5.16, 5.30.

Modified from Moore K, Agur A. *Essential Clinical Anatomy*, 2E. Baltimore: Lippincott Williams & Wilkins, 2002. Figures 5.07, 5.13.

Modified from Moore K, Dalley AF. *Clinically Oriented Anatomy*, 4E. Baltimore: Lippincott Williams & Wilkins, 1999. Figures 5.09, 5.23, 5.25, 5.26.

CHAPTER 6

Modified from Netter F. *Netter's Atlas of Human Anatomy*, 3E. Carlstadt, NJ: Icon Learning System, 2002. Figures 6.16, 6.22, 6.23, 6.33.

CHAPTER 7

Modified from Agur A. *Grant's Atlas of Anatomy*, 9E. Baltimore: Lippincott Williams & Wilkins, 1991. Figures 7.02, 7.03, 7.22, 7.27, 7.70, 7.79, 7.92.

Modified from Agur A, Dalley AF. *Grant's Atlas of Anatomy*, 11E, Baltimore: Lippincott Williams & Wilkins, 2005. Figures 7.09, 7.40, 7.53, 7.95.

Redrawn from *Bailey's Textbook of Histology*, 16E, 1978, pshr 697, 22.28 Figure 7.94.

Modified from Clemente CD. *Anatomy Dissector*. Baltimore: Lippincott Williams & Wilkins, 2002. Figures 7.01, 7.13, 7.21, 7.26, 7.28, 7.29, 7.37.

Modified from Hansen. *Essential Anatomy Dissector*, 2E. Baltimore: Lippincott Williams & Wilkins, 2002. Figure 7.76.

Modified from Moore K, Agur A. *Essential Clinical Anatomy*, 2E. Baltimore: Lippincott Williams & Wilkins, 2002. Figure 7.09.

Modified from Moore K, Dalley AF: *Clinically Oriented Anatomy*, 4E. Baltimore: Lippincott Williams & Wilkins, 1999. Figure 7.80.

Modified from Netter F. *Netter's Atlas of Human Anatomy*, 3E. Carlstadt, NJ: Icon Learning System, 2002, Figures 7.56, 7.62, 7.71, 7.84.

Modified from Woodburne. *Essentials of Human Anatomy*, 9E, 1994. Figure 7.41.

PREFACE

The first edition of *Grant's Dissector* appeared in 1940. Its 12 previous editions have been used by countless health professionals for over 60 years. During those years, the time devoted to the study of gross anatomy has diminished dramatically, and the 13th edition of *Grant's Dissector* has been modified with that in mind.

A refocusing of content

Grant's Dissector was originally designed as an instruction manual for dissection by the regional approach. The 13th edition continues in this approach but has been rewritten to make the dissection instructions concise and minimize extraneous material. This refocusing is intended to make the scope and detail of the dissector more appropriate to today's gross anatomy curriculum. The student is encouraged to rely upon *Grant's Dissector* for dissection instructions and to use a textbook such as *Clinically Oriented Anatomy* and a quality atlas such as *Grant's Atlas* to provide anatomical details.

Changes to dissection order

In addition to the refocusing of the dissector's content, the order of dissection has been modified in the 13th edition. The first chapter covers the dissection of the back, followed by the upper limb, thorax, abdomen, pelvis and perineum, lower limb, and head and neck. This change in dissection order was made to accommodate courses that begin by dissecting the back for traditional reasons: The dissection experience is less emotionally traumatic for students if they begin with the body in the prone position. However, the chapters are written so that the dissection units can be used in any order that fits the needs of the individual course.

New chapter organization and other key features

Each chapter in the 13th edition is consistently organized with several new features. First, each chapter begins with a brief study of **surface anatomy**. Then, **osteology** is presented in a concise way to provide the student with important foundation structures that will aid in localization of soft tissue structures. Each dissection unit begins with a brief overview, called **"Before you dissect...,"** of what is to be accomplished during the dissection session. The **dissection instructions** are then presented in numbered sequence so that the dissector can perform a step, then return quickly to the appropriate place on the page to get the next dissection instruction. Lastly, each dissection concludes with a series of review exercises, called **"After you dissect...,"** that highlight the important features of the dissection and encourage the synthesis of information. These modifications are intended to improve student learning and ease of use.

Many new illustrations appear in the 13th edition of Grant's Dissector. A number of these illustrations are designed to show the dissection at various stages of completion. The illustrations are not intended to take the place of atlas figures. The dissection instructions contain references to appropriate illustrations in the four leading anatomical atlases:

- *Grant's Atlas of Anatomy*, 11th edition, by Anne Agur and Ming Lee
- *Atlas of Human Anatomy*, 3rd edition, by Frank H. Netter and John T. Hansen (Consulting Editor)
- *Anatomy: A Regional Atlas of the Human Body*, 4th edition, by Carmine Clemente
- *Color Atlas of Anatomy: A Photographic Study of the Human Body*, 5th edition, by Johannes W. Rohen, Chihiro Yokochi, and Lutjen-Drecoll

Anatomical terminology has been undergoing revision for many years. The terminology used in the 13th edition of *Grant's Dissector* agrees with *Terminologia Anatomica*. This modification brings the manual into alignment with recent editions of textbooks and atlases, thereby reducing one source of confusion for students of gross anatomy.

The changes described above are intended to increase the adaptability of *Grant's Dissector* to a variety of dissection needs. Since the chapters are written to stand alone, the dissection sequence can be modified or regional units may be eliminated with a minimum amount of effort. This increase in flexibility is intended to make *Grant's Dissector* the obvious choice to support comprehensive dissection in a changing curricular environment.

ACKNOWLEDGMENTS

Grant's Dissector has enjoyed many years of success. This is due to excellent writing by Dr. J.C.B. Grant and the masterful way in which Dr. Eberhardt K. Sauerland has edited the most recent 6 editions. It is indeed a daunting task to undertake the editor's role for such a significant work, and I thank Dr. Sauerland for permitting me the privilege.

Students are the reason that a teacher exists and I cannot adequately express their impact on me. For over 25 years, I have had the pleasure of working in the lecture hall and dissection laboratory with literally thousands of very talented students. Nearly every day I find myself learning something new about anatomy and about adult learning processes. To my students of the past I express my gratitude for what they have taught me - lessons that have resulted in the modifications that appear in the 13th edition of *Grant's Dissector*. More specifically, I owe a debt of gratitude to the following members of the class of 2007 who took time from their studies to review portions of the manuscript and provide helpful criticism: James Blachly, Andrew Coble, Rani Haley, Thad Hardin, James Ireland, Patrick Kennedy, Leslye McClelland, Joel McLarry, Catherine Oswald, Ray Peeples, Robin Reed, Kirk Reynolds, Aubrey Slaughter and Tony Terry. A special thanks to Deborah Lieber whose editorial skills are second to none and who gave freely of her time to review large portions of the manuscript.

It is not possible to complete a work of this nature without involving one's colleagues. I would like to acknowledge several individuals with whom I teach gross anatomy, for each is a master of anatomical education in his own right. Thanks to David Davies and Bruce Newton for reviewing selected chapters of the manuscript. Kevin Phelan deserves special recognition for his review of the entire manuscript. Their critical focus and attention to detail was exactly what was needed to make this a better dissection manual, and I thank them for their contributions.

It has been a pleasure to work with the professionals that constitute the Lippincott, Williams & Wilkins team. I want to thank Betty Sun, Executive Editor, for her willingness to iron out the details and give a new author a chance. I gratefully acknowledge the talents of Amy Oravec, Managing Editor, and Kathleen Scogna, Senior Developmental Editor, who kept the project on track. Thanks also to Wayne Hubbel, Illustration Coordinator, and Joe Schott, Marketing Manager. The artwork has undergone major revision. To place a magnifying glass on their enormous artistic talents, I would like to thank Rob Duckwall of Dragonfly Media Group, Mary Anna Barrett-Dimes, and Wayne Hubbel.

Last but most importantly, I want to thank my wife, Suzanne. She never complained as I poured myself into this project over many months at the exclusion of everything else, and she always revived me with kind words of encouragement when fatigue had sent my spirits flagging. She deserves as much credit for the completion of this project as I do.

Patrick W. Tank

CONTENTS

INTRODUCTION

"The essence of good dissection is to display each structure fully, clearly, and cleanly. This takes time but it is time well spent. No mental picture can ever be obtained if blood vessels and nerves are seen only through a maze of fat and areolar tissue, if muscles are never cleaned to their bony attachments, and if ligaments are left undefined as to their margins, direction of their fibers and attachments. Cleaning a structure, therefore, means much more than the mere recognition of its existence.

There are certain disadvantages inherent in the art of dissection. It is, for example, apparent that dissection must proceed from the surface to the depths. In this very obvious limitation lies the explanation of the somewhat discouraging fact . . . that small and sometimes irritatingly insignificant structures are the first to be the subject of inquiry. The larger and often more important structures are only met as the dissection proceeds. *It is, therefore, vital to the understanding of a region that it should be reviewed as a whole when its dissection is completed.* What was at first perhaps a little obscure then becomes clear."

—J.C.B. Grant

Excerpt from the 5th edition of Grant's Dissector, 1959

As you undertake the study of human anatomy, it is important to heed the words of Dr. Grant. Clean dissection yields great reward but comes at the expense of time and effort. The time is but brief if weighed against the length of your career during which the gained knowledge will be put to use. If you view the study of anatomy from this perspective, you will be rewarded with the most memorable learning experience of your medical career.

CARE OF THE CADAVER

The cadaver that will be used for dissection was donated by a person who wished to make a contribution to your education as a physician. It is not possible to put into words the emotions experienced by that individual as he or she made the decision to become a body donor. It goes without saying that the value of the gift that the donor has made to you cannot be measured, and can only be repaid by the proper care and use of the cadaver. The cadaver must be treated with the same respect and dignity that are usually reserved for the living patient.

On entering the laboratory, you will find that the cadaver has been embalmed with a strong fixative. The veins are sometimes full of clotted blood, and sometimes empty. In some schools, the arteries are injected with red dye. The whole body has been kept moist by wrappings or by submersion under preservative fluid. Desiccation of the cadaver will quickly render the specimen useless for study because once a part has been allowed to become dry, it can never be fully restored. Therefore, expose only those parts of the body to be dissected. Inspect every part of the body periodically and moisten the wrappings during each dissection session.

DISSECTION INSTRUMENTS

It is generally true that large dissection equipment (hammers, chisels, saws, etc) is provided for you but personal dissection instruments must be purchased. The well-equipped dissector should have the following instruments (Fig. I.01):

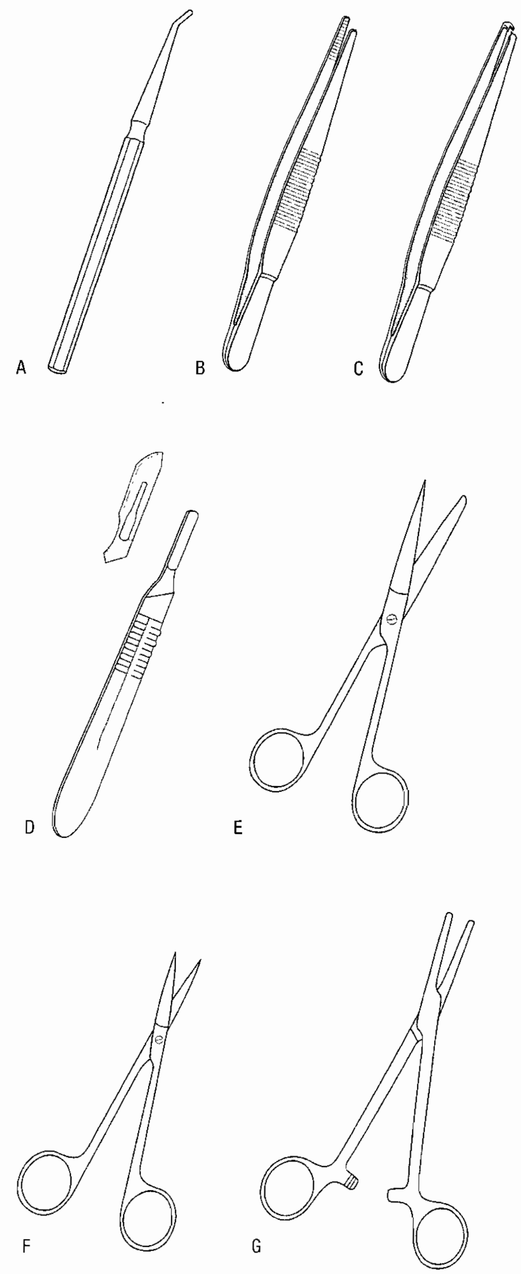


Figure I.01. Personal dissection instruments: **A.** Probe. **B.** Forceps. **C.** Tissue (rat-toothed) forceps. **D.** Scalpel and removable blade. **E.** Large scissors. **F.** Small scissors. **G.** Hemostat.

- **Probe** – the primary dissecting tool, after your fingers. A probe is designed to tear connective tissue and allow the user to feel nerves and vessels before they are damaged.
- **Forceps** – used to lift and hold vessels, nerves, and other structures while blunt dissecting with a probe. Two pairs of forceps are needed. One pair should have tips that are blunt and rounded, and the gripping surfaces should be corrugated. The second pair should have teeth (also known as tissue forceps or rat-toothed forceps) for gripping tissue.
- **Scalpel** – primarily used as a skinning tool. Scalpels are not recommended for general dissection because they cut small structures without allowing you to feel them. The scalpel handle should be made of metal (not plastic). The blade should be approximately 3.5 to 4 cm long. The cutting edge must have some convexity near the point. A sharp blade must be used at all times because no one can do good work with a dull scalpel. Therefore, a sufficient supply of blades will be needed.
- **Scissors** – useful in cutting, blunt dissection, and transection. Two pairs of scissors are recommended: a large, heavy pair of dissecting scissors (approximately 15 cm in length) and a small pair of scissors with two sharp points for the dissection of delicate structures.
- **Hemostat** – a powerful grasping tool. The disadvantage of using a hemostat is that it cannot be repositioned quickly like forceps can, thereby slowing progress.

GLOSSARY OF DISSECTION TERMS

This dissection manual repeatedly uses a number of dissection terms. Before beginning to dissect, learn the meaning of the following:

- **Dissect** – to cut apart. In the context of this dissection manual, the meaning of dissect is to tear apart. The dissection approach throughout this manual is to dissect as much as possible with the fingers, to next use a probe, and to then use scissors. A scalpel is used only as a tool of last resort for crude cuts or to dissect extremely tough connective tissues.
- **Blunt dissection** – to separate structures with your fingers, a probe or scissors.
- **Scissors technique** – a method of blunt dissection in which the tips of a closed pair of scissors are inserted into connective tissue and then opened, tearing the connective tissue with the back edge of the tips (Fig. I.02). The scissors technique is an effective way to dissect vessels and nerves.
- **Sharp dissection** – to dissect by use of a scalpel. Sharp dissection is discouraged and will be recommended only in rare situations.

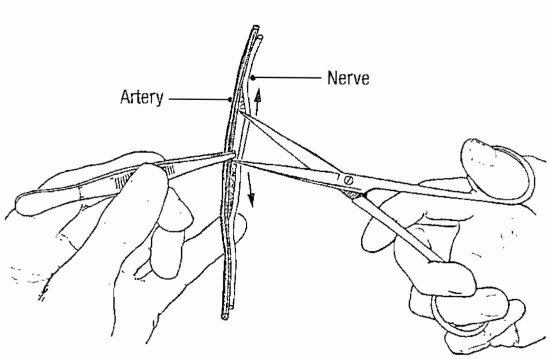


Figure I.02. Scissors technique for separating structures. Closed scissors are inserted between structures, then opened.

- **Clean** – to remove fat and connective tissue by means of blunt dissection (preferred) or sharp dissection.
  - **Clean the border of a muscle** – to define the border by using fingers or a probe to break the loose connective tissue that binds the muscle to surrounding structures.
  - **Clean a nerve** – to use a probe (or scissors technique) to break the connective tissue around the nerve for purposes of observing its relationships and branches.
  - **Clean a vessel** – to use a probe (or scissors technique) to strip the fat and connective tissue off the surface of a vessel and its branches to illustrate its relationships.
- **Define** – to use blunt dissection to enhance a structure to better illustrate its relationships. Defining a structure usually involves bluntly dissecting the loose connective tissue away from it by use of a probe.
- **Reflect** – to fold back from a cut edge, as in folding back both halves of a cut muscle. The reflected tissue should remain attached to the specimen.
- **Retract** – to pull a structure to one side to visualize another structure that lies more deeply. Retraction is a temporary displacement and is not intended to harm the retracted structure.
- **Transect** – to cut in two in the transverse plane, as in transection of a muscle belly or tendon.
- **Strip a vein** – to remove the vein and its tributaries from the dissection field so that the artery and related structures can be seen more clearly. Veins are stripped by blunt dissection using a probe.

ANATOMICAL POSITION

Anatomists describe structures with the body in the *anatomical position*. In the anatomical position, the person stands erect with the feet together, arms by the sides, and the palms facing forward (Fig. I.03). During dissection, structures are described as though the body were in the anatomical position, even though the cadaver is lying on the dissection table. When encountering

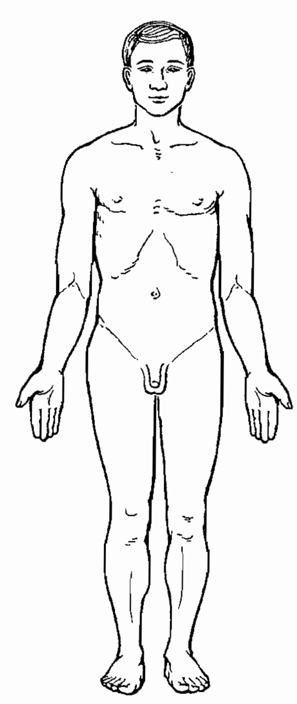


Figure I.03. Anatomical position

a structure during dissection, be aware of its position, its relationship to other structures, its size and shape, its function, its blood supply, and its nerve supply. Learn to give an accurate account of each important structure in an orderly and logical fashion by describing it to your laboratory partners. Always base your descriptions on the anatomical position.

Before beginning to dissect, consult your textbook for a description of **anatomical planes**, and a definition of **terms of relationship and comparison**, **terms of laterality**, and **terms of movement**. These terms form the language of anatomy and it is not possible to understand anatomical descriptions without being able to understand these terms.

ANATOMICAL VARIATION

All bodies have the same basic architectural plan, but no two bodies are identical. Minor variations commonly occur and should be expected. You should learn normal (average) anatomy rather than the variation unless specifically instructed to do otherwise. Take time during each dissection period to view several dissections so that you can learn to appreciate anatomical variations.

DAILY DISSECTION ROUTINE

To get the most out of dissection, it is recommended that you establish a routine approach to each day's dissection. Some suggestions are offered:

- **Prepare before laboratory**. Read the dissection assignment and become familiar with the new vocabulary, the structures to be dissected, and the dissection approach. You must deliberately search for structures and advance preparation will make the exercise go more quickly.
- **Use a good atlas** in the dissection laboratory. This dissection manual provides references to four atlases to help you quickly find illustrations that support the dissection.
- **Palpate bony landmarks** and use them in the search for soft tissue structures.

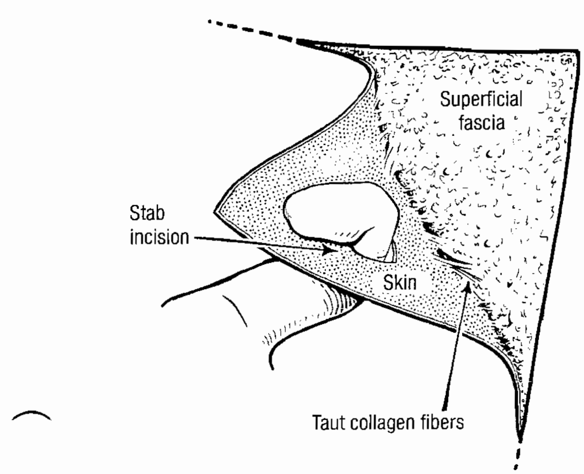


Figure I.04. When removing skin, make a stab incision to help you apply traction. Use the scalpel blade to cut the collagen fibers from the deep surface of the skin where the fibers are taut.

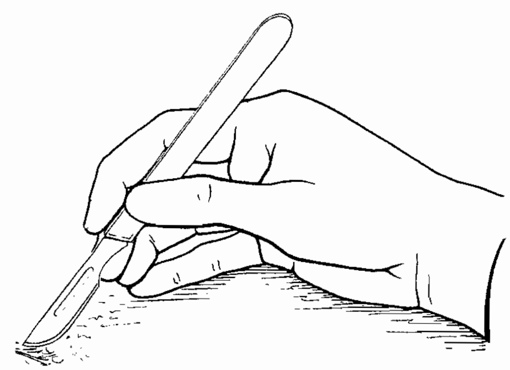


Figure I.05. When dissecting, rest the hand to reduce unsteady movements.

- **Remove fat, connective tissue, and smaller veins** to clean up the dissection.
- **Review the completed dissection** at the end of the dissection period and again at the start of the next dissection period. To help you do this, review exercises are included at strategic points in each chapter.
- **Complete each dissection before proceeding to the next** because each new dissection is an extension of the previous dissection.

LAB SAFETY

While in the laboratory, protect your clothing by wearing a long laboratory coat or apron. For sanitary reasons, this outer layer of clothing should not be worn outside of the dissection laboratory. Do not wear sandals or open-toed shoes in the laboratory, because a dropped scalpel can seriously injure your foot. Gloves must be worn to prevent contact with human tissue and fixatives. When cutting bones, wear glasses or goggles to protect your eyes against flying chips.

SKIN REMOVAL

Because skin removal is the first step in dissection, a few suggestions are offered to help you get started. A variable amount of subcutaneous tissue (also called superficial fascia) lies immediately deep to the skin. The subcutaneous tissue contains fat, cutaneous nerves, and superficial blood vessels. Throughout this dissection manual, when you are instructed to skin a region, **the skin should be removed and the subcutaneous tissue should be left behind**. Subsequent dissection instructions will be provided for dissection and removal of the subcutaneous tissue.

The thickness of skin varies from region to region. For example, the skin is relatively thin on the anterior surface of the forearm and it is considerably thicker over the back. Generally, skin incisions should not extend into the subcutaneous tissue. To begin skinning, raise the skin at the intersection of two incision lines by use of toothed forceps and the scalpel blade. Once a skin flap has been raised, place traction on the skin as it is being removed and direct the scalpel blade toward the deep surface of the skin to cut the taut collagen fibers (Fig. I.04). To steady your hand, rest it against the cadaver and hold the scalpel as you would hold a pencil (Fig. I.05). Make short sweeping motions and, to prevent accidents, do not work too close to your laboratory partners.

CHAPTER 1

THE BACK

The back region contains the **superficial muscles of the back (posterior thoracoappendicular muscles)**, the **intermediate muscles of the back,** and the **deep muscles of the back.** All of these muscles attach to the vertebral column. The vertebral column serves the dual purpose of forming the axis of the body and providing a protective bony covering for the spinal cord.

SURFACE ANATOMY

The surface anatomy of this region may be studied on a living subject or on the cadaver. In the cadaver, fixation may make it difficult to distinguish bone from well-preserved soft tissues. Turn the cadaver to the prone position (face down) and palpate the following structures (Fig. 1.01): **[N 145]**

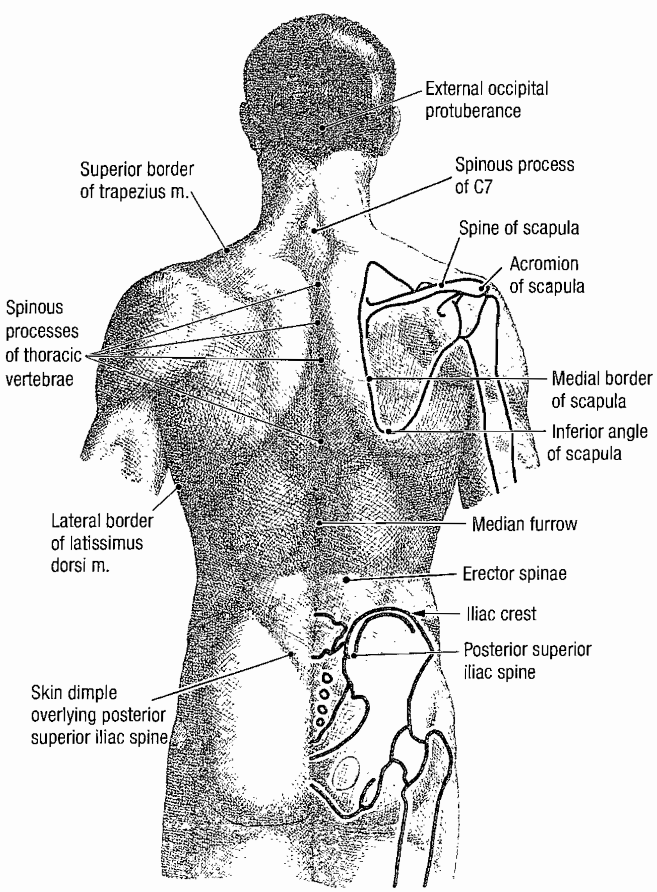


Figure 1.01. Surface anatomy of the back.

KEY TO REFERENCES

G = Grant's Atlas, 11th ed., page number
N = Netter's Atlas, 3rd ed., plate number
R = Rohen's Color Atlas of Anatomy, 5th ed., page number
C = Clemente's Atlas, 4th ed., page number

- **External occipital protuberance**
- **Superior border of the trapezius muscle**
- **Spinous process of the 7th cervical vertebra (vertebra prominens)**
- **Spine of the scapula** (at vertebral level T3)
- **Acromion of the scapula**
- **Medial (vertebral) border of the scapula**
- **Inferior angle of the scapula** (at vertebral level T7)
- **Spinous processes of thoracic vertebrae**
- **Erector spinae muscle** (most noticeable in the lumbar region)
- **Median furrow**
- **Lateral border of the latissimus dorsi muscle (posterior axillary fold)**
- **Iliac crest** (at vertebral level L4)
- **Posterior superior iliac spine**

SKELETON OF THE BACK

Refer to a skeleton. On the **scapula**, identify (Fig. 1.02): **[G 459; N 404; R 359; C 70]**

- **Acromion**
- **Spine**
- **Superior angle**
- **Medial (vertebral) border**
- **Inferior angle**

On the **ilium**, identify (Fig. 1.02): **[G 299; N 152; R 184; C 249]**

- **Iliac crest**
- **Posterior superior iliac spine**

On the **occipital bone**, identify (Fig. 1.02):

- **External occipital protuberance (inion)**
- **Superior nuchal line**

On the **temporal bone**, identify (Fig. 1.02):

- **Mastoid process**

The **vertebral column** (Fig. 1.02) consists of 33 vertebrae: 7 cervical (C), 12 thoracic (T), 5 lumbar (L), 5 sacral (S), and 4 coccygeal (Co). The upper 24 vertebrae (cervical, thoracic, and lumbar) allow flexibility and movement of the vertebral column, whereas the sacral vertebrae are fused to provide rigid support of the pelvic girdle. A typical thoracic vertebra will be described, and the cervical and lumbar vertebrae will be compared to it. **[G 276; N 146; R 189; C 422]**

Refer to a disarticulated **thoracic vertebra** and identify (Fig. 1.03): **[G 286; N 147; R 186; C 423]**

- **Body**
- **Vertebral arch** – formed by the combination of pedicles and laminae
- **Pedicle** (2)
- **Lamina** (2)
- **Vertebral foramen**

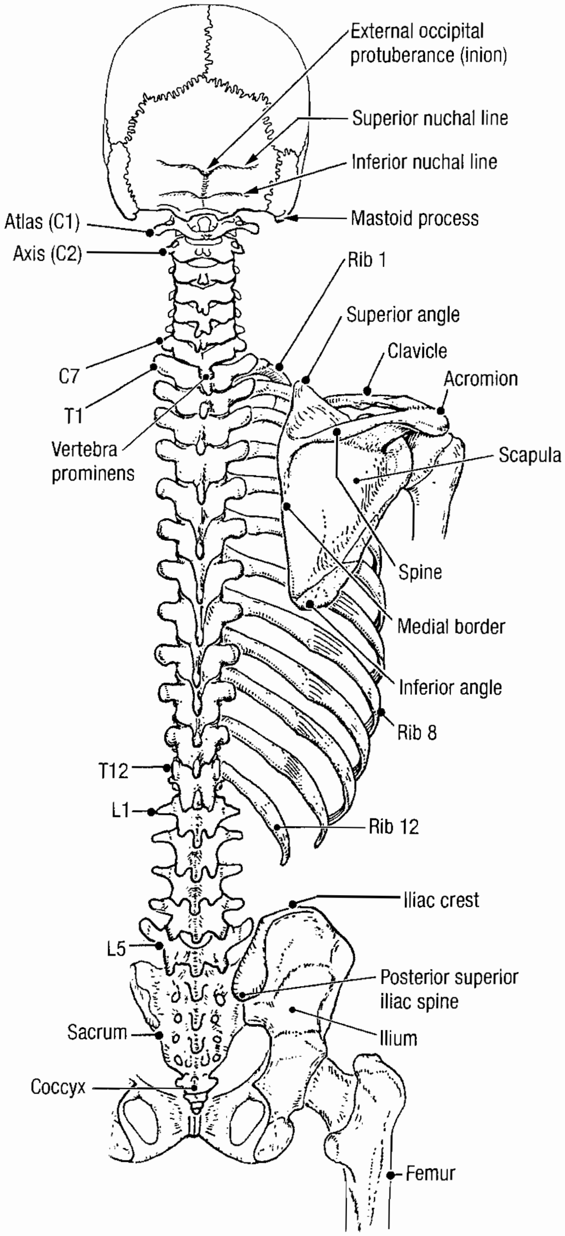


Figure 1.02. Skeleton of the back and vertebral column.

- **Transverse process** (2)
- **Transverse costal facet**
- **Spinous process**
- **Articular processes** – superior and inferior
- **Vertebral notches** – superior and inferior
- **Costal facets** – superior and inferior

The spinous process of a thoracic vertebra is long, slender, and directed inferiorly over the spinous process of the vertebra that is inferior to it. Articulation with ribs is a unique characteristic of thoracic vertebrae. The head of a rib articulates with the bodies of two adjacent vertebrae (Fig. 1.04). The tubercle of a rib articulates with the transverse costal facet of the thoracic vertebra of the same number (i.e., the tubercle of rib 5 articulates with the transverse costal facet of vertebra T5). An **intervertebral disk** and the **articular processes** unite two adjacent vertebrae. The vertebral notches of two adjacent vertebrae combine to form an **intervertebral foramen**. A spinal nerve passes through the intervertebral foramen.

Cervical vertebrae differ from thoracic vertebrae in the following ways (Fig. 1.05): cervical vertebrae have smaller bodies,

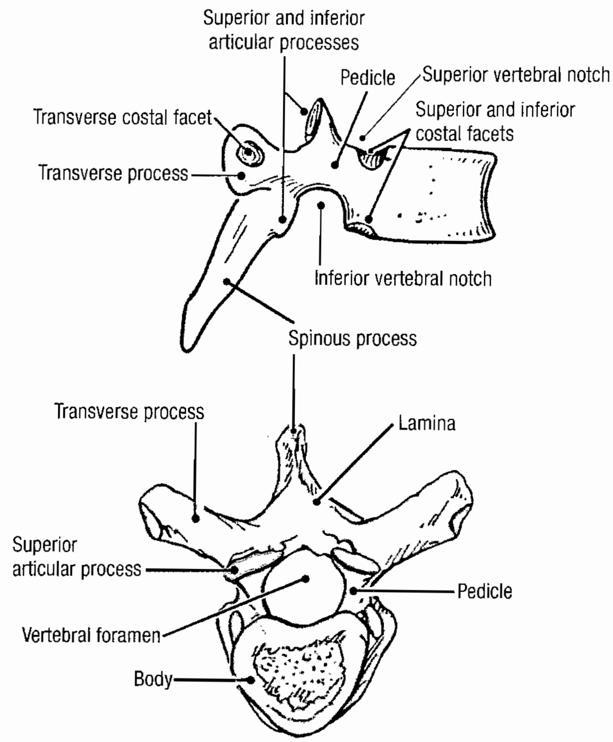


Figure 1.03. Typical thoracic vertebra in lateral and superior view.

larger vertebral foramina, shorter spinous processes that bifurcate at the tip, and transverse processes that contain a foramen transversarium. On an articulated skeleton, identify the following features common to all cervical vertebrae: **[G 284; N 15; R 186; C 418]**

- **Transverse process**
- **Foramen transversarium**
- **Spinous process**

On a skeleton, observe the following features of individual cervical vertebrae:

- **Atlas** (C1) – does not have a body.
- **Axis** (C2) – has the **dens**, which is the body of C1 that has become fused to C2 during development.
- **Vertebra prominens** (C7) – has the most prominent spinous process in the cervical region, hence its name.

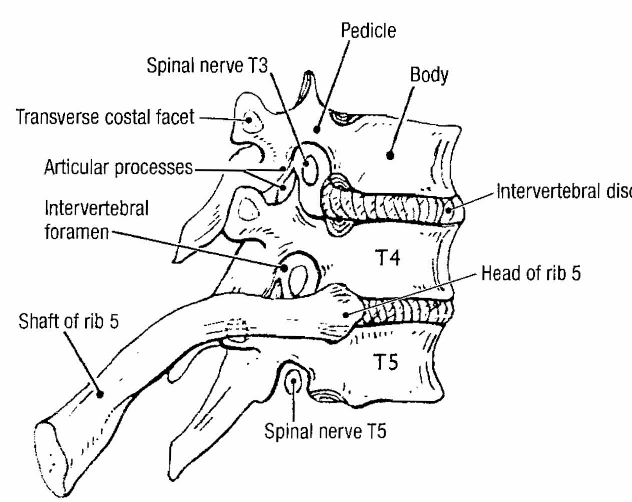


Figure 1.04. Part of the thoracic vertebral column.

Lumbar vertebrae differ from thoracic vertebrae in the following ways (Fig. 1.05): lumbar vertebrae have larger bodies, broad spinous processes that project posteriorly, and they do not have articular facets for ribs. On a skeleton, observe the lumbar vertebrae and notice that their spines do not overlap like the spines of thoracic vertebrae. **[G 289; N 148; R 186; C 426]**

The **sacrum** is formed by five fused vertebrae and it does not have identifiable spines or transverse processes. On the dorsal surface of the sacrum, identify (Fig. 1.06): **[G 293; N 150; R 187; C 428]**

- **Median sacral crest**
- **Posterior (dorsal) sacral foramina**
- **Sacral hiatus**

The **coccyx** is a small triangular bone formed by four rudimentary coccygeal vertebrae that are fused together (Fig. 1.06).

SKIN AND SUPERFICIAL FASCIA

Before you dissect . . .

The order of dissection will be as follows: the skin will be removed from the back, posterior surface of the neck, and posterior surface of the proximal upper limb. Posterior cutaneous nerves will be studied. The superficial fascia will then be removed.

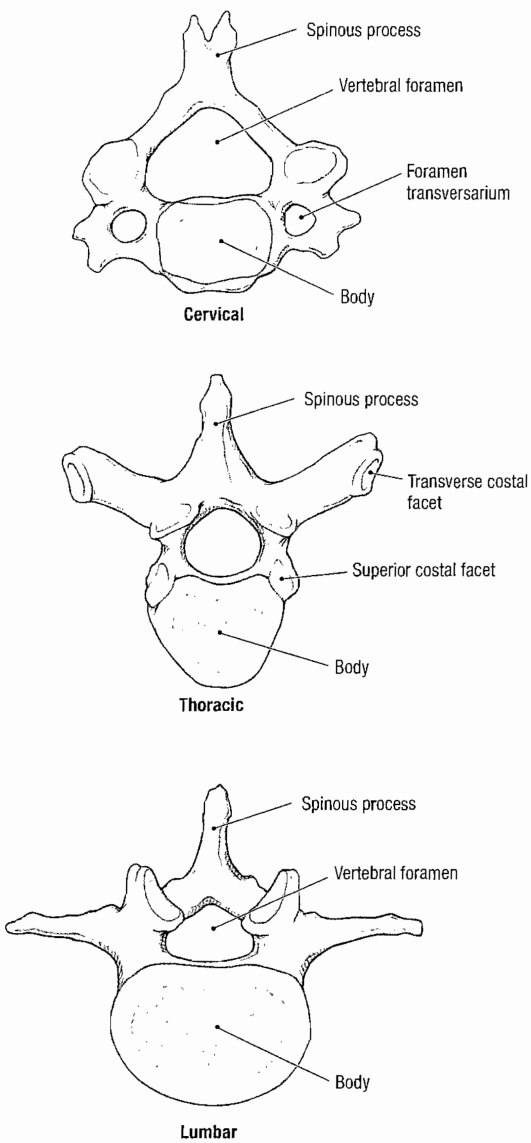


Figure 1.05. Comparison of cervical, thoracic, and lumbar vertebrae.

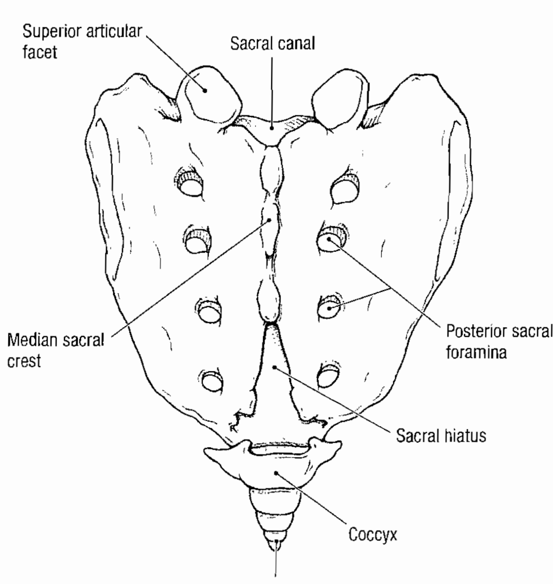


Figure 1.06. Sacrum and coccyx.

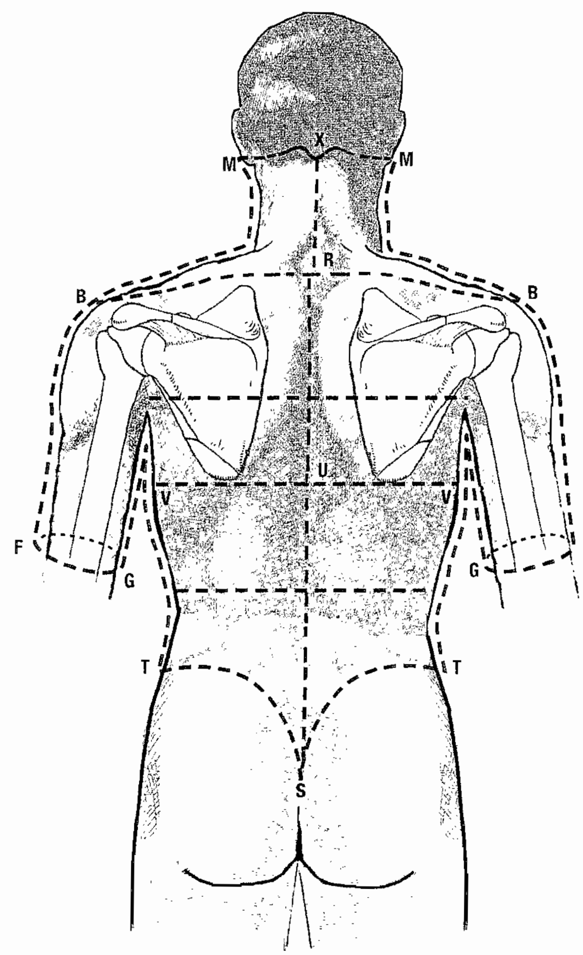


Figure 1.07. Skin incisions.

Dissection Instructions

SKIN INCISIONS

1. Refer to Figure 1.07.
2. Use a scalpel to make a vertical skin incision in the midline from the external occipital protuberance (X) to the tip of the coccyx (S). The skin is approximately 6-mm-thick in this region.
3. Make an incision from S to the midaxillary line (T). This incision should pass approximately 3 cm inferior to the iliac crest.
4. At the level of the inferior angle of the scapula, make a transverse skin incision from the midline (U) to the midaxillary line (V). To facilitate skinning, make a parallel transverse incision above and below this one.
5. Make a transverse skin incision from R to B, superior to the scapula and superior to the acromion. Extend this incision to point F, approximately halfway down the arm.
6. At point F, make an incision around the anterior and posterior surfaces of the arm, meeting on the medial side (G). If the upper limb has been dissected previously, this incision has already been made.
7. Make a skin incision that begins at G on the medial surface of the arm and extends superiorly to the axilla. Extend this incision inferiorly along the lateral surface of the trunk, through V to T.
8. Make a transverse skin incision from the external occipital protuberance (X) laterally to the base of the mastoid process (M).
9. Make an incision along the lateral surface of the neck and superior border of the trapezius muscle (M to B).
10. Remove the skin from medial to lateral. Detach the skin and place it in the tissue container.

SUPERFICIAL FASCIA

1. In the superficial fascia, locate the **occipital artery** and the **greater occipital nerve** (Fig. 1.08). First, find the occipital artery and then look on its medial side for the greater occipital nerve. The greater occipital nerve is the dorsal primary ramus of spinal nerve C2. The greater occipital nerve pierces the **trapezius muscle** approximately 3 cm inferolateral to the **external occipital protuberance**. The deep fascia in this area is very dense and tough. Therefore, it may be difficult to find the greater occipital nerve, even though it is large. **[G 307; N 171; R 212; C 414]**
2. Read a description of the **dorsal primary ramus of a spinal nerve**. The **posterior cutaneous branches** of the dorsal primary rami pierce the trapezius muscle or latissimus dorsi muscle to enter the superficial fascia (Fig. 1.08). To save time, make no deliberate effort to display posterior cutaneous branches of the dorsal primary rami. **[G 20; N 187; R 204]**
3. Reflect the superficial fascia of the back from medial to lateral. Detach the superficial fascia by cutting it along the skin incision lines and place it in the tissue container.

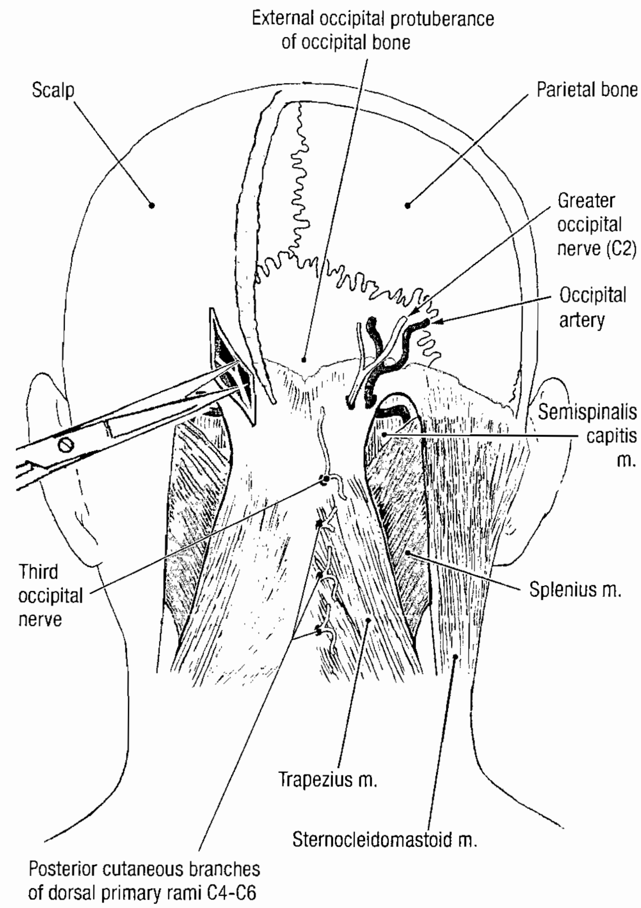


Figure 1.08. Greater occipital nerve and occipital artery.

4. In the neck, reflect the superficial fascia only as far laterally as the superior border of the trapezius muscle. *Do not cut the deep fascia along the superior border of the trapezius muscle.* The accessory nerve is superficial at this location and it is in danger of being cut.

After you dissect . . .

Review the branching pattern of a typical spinal nerve and understand that cutaneous branches of the dorsal primary rami innervate the skin of the back. Study a dermatome chart and become familiar with the concept of segmental innervation. **[G 331; N 157; C 404]**

SUPERFICIAL MUSCLES OF THE BACK

Before you dissect . . .

The **superficial muscles of the back are** also called the **posterior thoracoappendicular muscles** because they attach to the axial skeleton and the upper limb. There are five superficial muscles of the back: **trapezius**, **latissimus dorsi**, **rhomboid major**, **rhomboid minor**, and **levator scapulae**.

The order of dissection will be as follows: the superficial surface of the trapezius muscle will be cleaned. The trapezius muscle will be examined and reflected. The latissimus dorsi muscle will be studied and reflected. The rhomboid major muscle

rhomboid minor muscle, and levator scapulae muscle will be studied. Dissection of the superficial back muscles should be performed bilaterally.

Dissection Instructions

TRAPEZIUS MUSCLE [G 307; N 167; R 212; C 407]

1. Clean the surface of the **trapezius muscle** (L. *trapezoides*, an irregular four-sided figure) (Fig. 1.09). *Do not disturb the superior border of the trapezius muscle.* Observe the proximal attachment of the trapezius muscle on the external occipital protuberance, the nuchal ligament, and the spinous processes of vertebrae C7 to T12.
2. The trapezius muscle has three parts with distinctly different actions:
   - **Superior part** of the trapezius muscle attaches to the lateral one-third of the clavicle and it elevates the scapula.
   - **Middle part** of the trapezius muscle attaches to the acromion and spine of the scapula and it retracts the scapula.
   - **Inferior part** of the trapezius muscle attaches near the medial end of the spine of the scapula and it depresses the scapula.
3. Reflect the trapezius muscle. Insert your fingers deep to the trapezius muscle, starting at the posterolateral border of the muscle (medial to the inferior angle of the scapula). Break the plane of loose connective tissue between the trapezius muscle and the deeper muscles of the back.

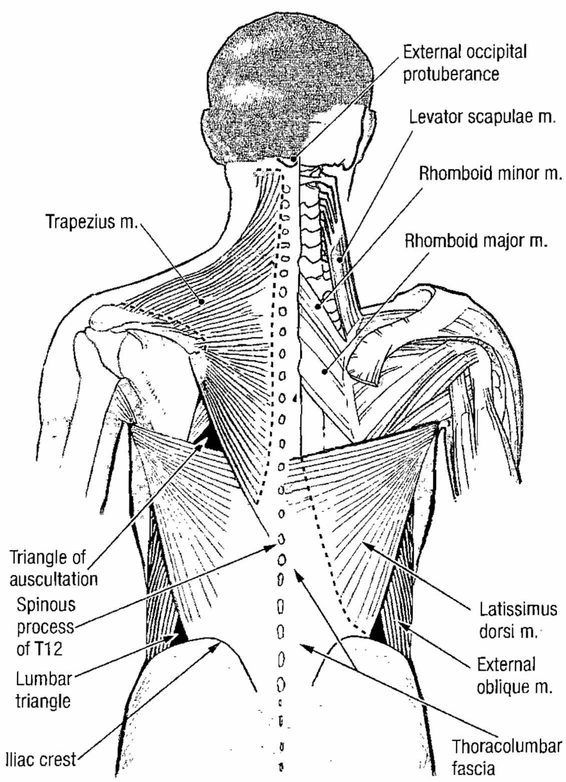


Figure 1.09. How to reflect the muscles of the back.

4. Use scissors to detach the trapezius muscle from its proximal attachment on the spinous processes and the nuchal ligament (dashed line, Fig. 1.09). Start inferiorly and continue the cut superiorly as far as the external occipital protuberance.
5. Use scissors to make a short transverse cut (2.5 cm) across the superior end of the trapezius muscle to detach it from the superior nuchal line. *Spare the greater occipital nerve, and do not extend the transverse cut beyond the border of the trapezius muscle.*
6. Use a scalpel to shave the trapezius muscle from its distal attachments on the spine and acromion of the scapula. Cut very close to the bone. Leave the trapezius muscle attached to the clavicle and cervical fascia.
7. Reflect the trapezius muscle superolaterally. Leave the cervical fascia attached along the superior border of the trapezius muscle to act as a hinge.
8. Study the deep surface of the reflected trapezius muscle. Find the plexus of nerves formed by the **accessory nerve** and **branches of the ventral primary rami of spinal nerves C3 and C4**. The accessory nerve provides motor innervation to the trapezius muscle; the branches of nerves C3 and C4 are sensory (proprioception). The superficial branch of the **transverse cervical artery** accompanies the nerves. Remove the transverse cervical vein to clear the dissection field.
9. The accessory nerve (cranial nerve XI) passes through the posterior triangle of the neck. Do not follow the nerve into the posterior triangle at this time. The posterior triangle will be dissected with the neck.

LATISSIMUS DORSI MUSCLE [G 307; N 167; R 212; C 407]

1. Clean the surface and define the borders of the **latissimus dorsi muscle** (L. *latissimus*, widest) (Fig. 1.09).
2. The proximal attachments of the latissimus dorsi muscle are the spines of vertebrae T7 to T12, the thoracolumbar fascia, and the iliac crest. The latissimus dorsi muscle also attaches to the inferior three or four ribs, lateral to their angles.
3. Note that the distal attachment of the latissimus dorsi muscle is the floor of the intertubercular sulcus on the anterior side of the humerus, but do not dissect this attachment. The latissimus dorsi muscle receives the **thoracodorsal nerve and artery** on its anterior surface near its distal attachment. The distal attachment of the latissimus dorsi muscle, its nerve, and its artery will be dissected with the upper limb.
4. Insert your fingers deep to the superior border of the latissimus dorsi muscle (medial to the inferior angle of the scapula) and break the plane of loose connective tissue between it and deeper structures. Raise the latissimus dorsi muscle enough to insert scissors and cut through its proximal attachment on the thoracolumbar fascia (dashed line, Fig. 1.09). Do not cut too close to the lumbar spinous processes.
5. Reflect the latissimus dorsi muscle laterally. It may have an attacment to the inferior angle of the scapula. Do not disturb its attachment to the scapula or its attachments to the inferior ribs.

RHOMBOID MAJOR AND RHOMBOID MINOR MUSCLES [G 308; N 170; R 212; C 407]

Clean the surface and borders of the **rhomboid (rhomboideus) minor muscle** and the **rhomboid major muscle** (Gr. *rhombos*, shaped like a kite). The plane of separation between the rhomboid muscles may not be obvious.

2. The proximal attachments of the rhomboid minor muscle are the nuchal ligament and the spinous processes of vertebrae C7 and T1. The distal attachment of the rhomboid minor muscle is the medial border of the scapula near the spine.
3. The proximal attachments of the rhomboid major muscle are the spinous processes of vertebrae T2 to T5. The distal attachment of the rhomboid major muscle is the medial border of the scapula inferior to the spine.
4. The rhomboid muscles retract the scapula, rotate the scapula to depress the glenoid cavity, and hold the scapula close to the thoracic wall.
5. Reflect the rhomboid muscles. Beginning at the inferior angle of the scapula, insert your fingers deep to the rhomboid major muscle and separate it from deeper muscles.
6. Use scissors to detach the rhomboid major muscle from its proximal attachments. Continue the cut superiorly and detach the rhomboid minor muscle from its proximal attachments. Reflect these two muscles laterally.

Examine the deep surface of the rhomboid muscles. Use blunt dissection to find the **dorsal scapular nerve** and **dorsal scapular vessels.** Remove the dorsal scapular vein to clear the dissection field. The dorsal scapular nerve and artery course parallel to the medial border of the scapula. The dorsal scapular artery may branch directly from the subclavian artery, or it may arise from the transverse cervical artery in which case it is also called the **deep branch of the transverse cervical artery.**

LEVATOR SCAPULAE MUSCLE [G 308; N 167; R 214; C 407]

1. Identify the **levator scapulae muscle** (L. *levare*, to raise).
2. Note that the proximal attachments of the levator scapulae muscle are the transverse processes of the upper four cervical vertebrae. Do not dissect its proximal attachments.
3. The distal attachment of the levator scapulae muscle is the superior angle of the scapula. The levator scapulae muscle can be seen only near its distal attachment.
4. The dorsal scapular nerve and artery supply the levator scapulae muscle. The levator scapulae muscle elevates the scapula and rotates the scapula to depress the glenoid cavity.

After you dissect . . .

Replace the superficial muscles of the back in their correct anatomical positions. Use the dissected specimen to review the proximal attachment, distal attachment, action, innervation, and blood supply of each muscle that you have dissected. Review the movements that occur between the scapula and the thoracic wall. Use an illustration to observe the origin of the transverse cervical artery and the dorsal scapular artery. Observe two triangles associated with the latissimus dorsi muscle: The **triangle of auscultation** and the **lumbar triangle (of Petit)** (Fig. 1.09).

CLINICAL CORRELATION

Triangles of the Back [G 4.28, 4.29; N 246]

The **triangle of auscultation** is bounded by the latissimus dorsi muscle, the trapezius muscle, and the rhomboid major muscle. Within the triangle of auscultation, intercostal space 6 has no overlying muscles. This area is particularly well-suited for auscultation (listening to sounds produced by thoracic organs, particularly the lungs).

The **lumbar triangle** is bounded by the latissimus dorsi muscle, the external oblique muscle, and the iliac crest. The floor of the lumbar triangle is the internal oblique muscle of the abdomen. On rare occasions, the lumbar triangle is the site of a lumbar hernia.

INTERMEDIATE MUSCLES OF THE BACK [G 308; N 167; R 219; C 408]

Dissection Instructions

The **intermediate muscles of the back** are the **serratus posterior superior muscle** and the **serratus posterior inferior muscle.** These are very thin muscles, which may be accidentally reflected with the rhomboid muscles or the latissimus dorsi muscle. If you do not see the serratus posterior muscles, look for them on the deep surface of the rhomboid muscles or the latissimus dorsi muscle.

1. The proximal attachments of the **serratus posterior superior muscle** are the nuchal ligament and the spinous processes of vertebrae C7 to T3. Its distal attachments are the superior borders of ribs 2 to 4, lateral to their angles.
2. The proximal attachments of the **serratus posterior inferior muscle** are the spinous processes of vertebrae T11 to L2. Its distal attachments are the inferior borders of ribs 8 to 12, lateral to their angles.
3. The serratus posterior muscles are respiratory muscles, and they are innervated by intercostal nerves.
4. Detach both serratus posterior muscles from the spinous processes. Reflect the muscles laterally, leaving them attached to the ribs.

DEEP MUSCLES OF THE BACK

Before you dissect . . .

The **deep muscles of the back** act on the vertebral column. There are many deep muscles of the back (Fig. 1.10) and only a few will be dissected: **splenius muscle, semispinalis capitis muscle,** and **erector spinae muscle**. All of the deep muscles of the back are innervated by dorsal primary rami of spinal nerves.

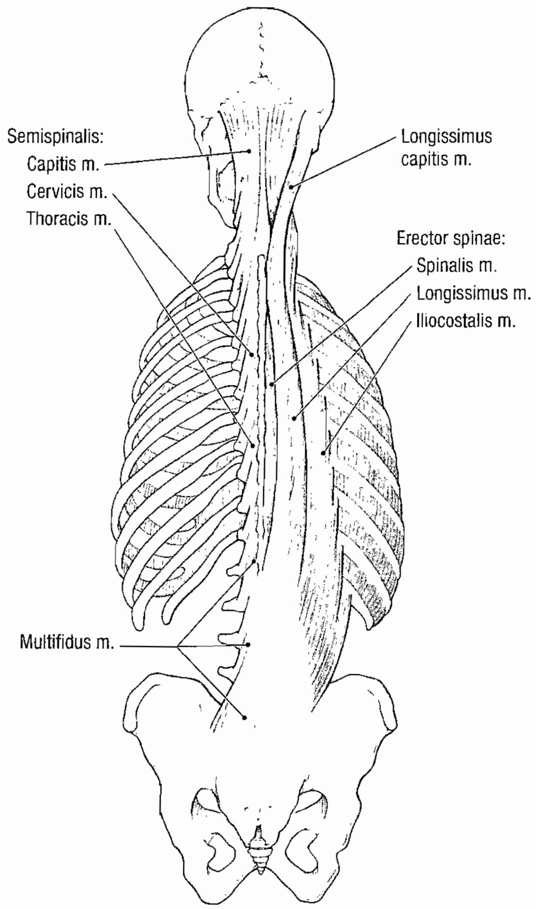


Figure 1.10. Deep muscles of the back.

The order of dissection will be as follows: the deep muscles of the posterior neck (splenius and semispinalis capitis) will be studied. The erector spinae muscle will be dissected and its component parts will be identified.

Dissection Instructions

SPLENIUS MUSCLE [G 309; N 167; R 212; C 408]

1. Identify the **splenius muscle** (Gr. *splenion*, bandage). The splenius muscle lies deep to the trapezius muscle and its fibers course obliquely across the neck. The proximal attachment of the splenius muscle is the nuchal ligament and the spinous processes of vertebrae C7 to T6.
2. The splenius muscle has two parts that are named according to their distal attachments:
   - **Splenius capitis muscle** (L. *caput*, head) is attached to the mastoid process of the temporal bone and the superior nuchal line of the occipital bone.
   - **Splenius cervicis muscle** (L. *cervix*, neck) is attached to the transverse processes of the vertebrae C1 to C4.
3. Detach the splenius muscle from the nuchal ligament and the spinous processes of vertebrae C7 to T6.
4. Reflect the muscle laterally, leaving its distal attachments undisturbed.

SEMISPINALIS CAPITIS MUSCLE [G 311; N 168; R 214; C 409]

1. Identify the **semispinalis capitis muscle** (L. *semi*, half; L. *spinalis*, spine) (Fig. 1.10). The semispinalis capitis muscle lies deep to the splenius muscle and its fibers course vertically, parallel to the long axis of the neck. The inferior attachments of the semispinalis capitis muscle are the transverse processes of the upper thoracic vertebrae.
2. The superior attachment of the semispinalis capitis muscle is the occipital bone between the superior and inferior nuchal lines. Note that the greater occipital nerve passes through the semispinalis capitis muscle.
3. Do not dissect the semispinalis capitis muscle further at this time.

ERECTOR SPINAE MUSCLE [G 309; N 168; R 214; C 409]

1. The erector spinae muscle lies deep to the serratus posterior muscles. The erector spinae muscle is composed of three columns of muscle.
2. Use a scalpel to incise the posterior surface of the **thoracolumbar fascia.** Use blunt dissection to remove it from the posterior surface of the erector spinae muscle.
3. The columns of the erector spinae muscle are fused at the level of their inferior attachments to the sacrum and ilium. Use your fingers to separate the columns at thoracic levels.
4. Identify the **three columns of the erector spinae muscle** (L. *erector*, one who erects) (Fig. 1.10):
   - **Spinalis muscle** forms the medial column of the erector spinae muscle. The inferior attachments of the spinalis muscle are on spinous processes. Its superior attachments are also on spinous processes. The spinalis muscle is present at lumbar, thoracic and cervical vertebral levels.
   - **Longissimus muscle** (L. *longissimus*, the longest) is the intermediate column of the erector spinae muscle. Its inferior attachment is on the sacrum and its superior attachments are the transverse processes of the thoracic and cervical vertebrae. Note that its most superior portion, the **longissimus capitis muscle**, attaches to the mastoid process of the temporal bone.
   - **Iliocostalis muscle** is the lateral column of the erector spinae muscle. Its inferior attachment is the ilium (iliac crest) and its superior attachments are on ribs (L. *costa*, rib).
5. All three columns of the erector spinae muscle extend the vertebral column when both sides work together. If only one side is active, the erector spinae muscle bends the vertebral column laterally toward the side that is active.

TRANSVERSOSPINAL GROUP OF MUSCLES [G 312; N 169; R 215; C 411]

The **transversospinal group of muscles** is located deep to the erector spinae muscle. The muscles in the transversospinal group attach to transverse processes and spinous

processes (Fig. 1.10). The muscles of the transversospinal group cause rotational and lateral bending movements between adjacent vertebrae and act to stabilize the vertebral column. A number of muscles comprise this group: **semispinalis**, **multifidus**, and, more deeply, **rotatores**. The semispinalis capitis muscle has been dissected. Do not dissect the other muscles of the transversospinal group.

After you dissect . . .

Use the dissected specimen to review the location, innervation, and action of each column of muscles in the deep group of back muscles.

SUBOCCIPITAL REGION

Before you dissect . . .

On a skull, identify (Fig. 1.02): **[G 592; N 8; R 50; C 498]**

- **Superior nuchal line**
- **Inferior nuchal line**
- **External occipital protuberance**
- **Foramen magnum**

On the **atlas** (C1 vertebra), identify (Fig. 1.11): **[G 282; N 15; R 193; C 418]**

- **Posterior tubercle**
- **Posterior arch**
- **Groove for the vertebral artery**
- **Transverse process**
- **Foramen transversarium**

On the **axis** (C2 vertebra), identify (Fig. 1.11):

- **Spinous process**
- **Transverse process**
- **Foramen transversarium**

The order of dissection will be as follows: the greater occipital nerve will be identified and followed deeply. The semispinalis capitis muscle will be reflected. The muscles that bound the suboccipital triangle will be identified. The contents of the suboccipital region (vertebral artery and suboccipital nerve) will be studied.

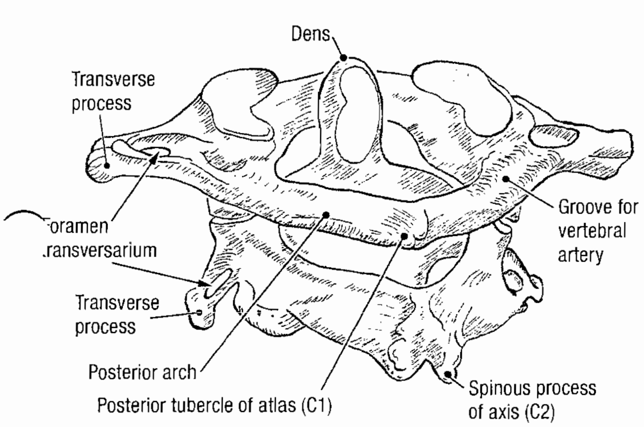


Figure 1.11. Features of the atlas (C1) and axis (C2).

Dissection Instructions

1. Identify the **semispinalis capitis muscle** (Fig. 1.12). **[G 314; N 169; R 227; C 409]**
2. Once again, find the **greater occipital nerve**. Use blunt dissection to trace the greater occipital nerve through the semispinalis capitis muscle. Detach the semispinalis capitis muscle close to the occipital bone and reflect it inferiorly.
3. Deep to the semispinalis capitis muscle, follow the greater occipital nerve to the lower border of the **obliquus capitis inferior muscle**. Note that the greater occipital nerve (C2) emerges between vertebrae C1 and C2.
4. Identify and clean the three muscles that form the **boundaries of the suboccipital triangle** (Fig. 1.12): **[G 317; N 171; R 228; C 417]**
   - **Obliquus capitis inferior muscle** forms the inferior boundary of the suboccipital triangle. Verify that the proximal attachment of the obliquus capitis inferior muscle is the spinous process of the axis (C2). Its distal attachment is onto the transverse process of the atlas (C1).

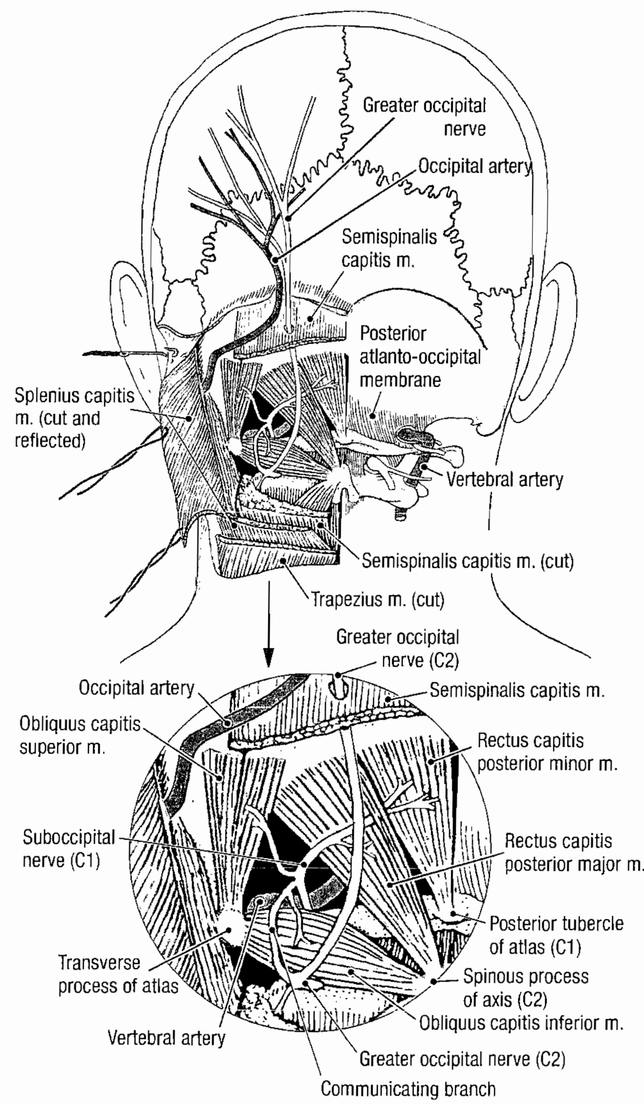


Figure 1.12. Suboccipital region

- **Rectus capitis posterior major muscle** forms the medial boundary of the suboccipital triangle. Confirm that the proximal attachment of the rectus capitis posterior major muscle is the spinous process of the axis. Its distal attachment is the inferior nuchal line of the occipital bone.
- **Obliquus capitis superior muscle** forms the lateral boundary of the suboccipital triangle. Confirm that the inferior attachment of the obliquus capitis superior muscle is the transverse process of the atlas. Its superior attachment is the occipital bone between the superior and inferior nuchal lines.

5. The muscles that bound the suboccipital triangle produce extension and lateral bending of the head at the atlanto-occipital joints, and rotation of the head at the atlantoaxial joints.
6. The **contents of the suboccipital triangle** are the **suboccipital nerve** and the **vertebral artery** (Fig. 1.12). Note that the suboccipital nerve (dorsal primary ramus of C1) emerges between the occipital bone and vertebra C1. The suboccipital nerve supplies motor innervation to the muscles of the suboccipital region. The suboccipital nerve is unique among dorsal primary rami in that it has no cutaneous distribution.
7. Identify the **vertebral artery**. Use an illustration to study the course of the vertebral artery through the neck and into the skull. **[G 319; N 130; R 166; C 458]**

After you dissect . . .

Review the actions of the suboccipital muscles. Review the distribution of the branches of a thoracic dorsal primary ramus and compare the thoracic pattern to the distribution of the dorsal primary rami of spinal nerves C1 to C3.

VERTEBRAL CANAL, SPINAL CORD, AND MENINGES

Before you dissect . . .

The **vertebral canal** is a bony tube formed by the stacked **vertebral foramina** of the **cervical vertebrae, thoracic vertebrae, lumbar vertebrae**, and the **sacral canal** (Fig. 1.13). The vertebral canal encloses and protects the **spinal cord**, its membranes (**spinal meninges**), and blood vessels. The spinal cord begins at the foramen magnum of the occipital bone and usually terminates in the adult at the level of the second lumbar vertebra. Because the spinal cord is shorter than the vertebral canal, *the spinal cord segments are found at higher vertebral levels than their names would suggest* (Fig. 1.13).

The spinal cord is not uniform in diameter throughout its length. It has a **cervical enlargement** (Fig. 1.13) that corresponds to spinal cord segments C4 to T1 and a **lumbar enlargement** that corresponds to spinal cord segments L2 to S3. There are 31 pairs of **spinal nerves** (8 cervical; 12 thoracic; 5 lumbar; 5 sacral; 1 coccygeal) (Fig. 1.13), which emerge between adjacent vertebrae. Spinal nerves are numbered according to the vertebra above. However, *in the cervical region, spinal nerves are numbered for the vertebra below, and the C8 spinal nerve does not have a correspondingly numbered vertebra.*

The order of dissection will be as follows: the erector spinae muscles will be removed to expose the laminae of the vertebrae. The laminae will then be cut and removed (laminectomy) to expose the spinal meninges. The spinal meninges will be examined and will be opened to expose the spinal cord. The spinal cord will then be studied.

Dissection Instructions

1. *Wear eye protection for all steps that require the use of a chisel, bone saw, or bone forceps.*
2. Use a scalpel to remove the erector spinae muscles bilaterally from vertebral levels C4 to S3. The laminae must be clearly exposed. Use scraping motions with a chisel to clean the laminae after the muscles have been removed.
3. Use a chisel or power saw to cut the **laminae** of vertebrae T6 to T12 on both sides of the spinous processes (Fig. 1.14). Make this cut at the lateral end of the laminae to gain wide exposure to the vertebral canal. The cutting instrument should be angled at 45 degrees to the vertical.
4. Use a scalpel to cut the interspinous ligaments between vertebrae T5 and T6 and between vertebrae T12 and L1. Leave the remaining interspinous ligaments undisturbed to maintain the laminectomy specimen intact.
5. Use a chisel to pry the six spinous processes and their laminae out as a unit. The dura mater will be undamaged.
6. Observe the **ligamenta flava** on the deep surface of the laminectomy specimen. The ligamenta flava connect the laminae of adjacent vertebrae.
7. Continue the laminectomy procedure superiorly and inferiorly from the opening in the vertebral canal. Exercise caution in lower lumbar and sacral regions, because the vertebral canal curves sharply posteriorly (Fig. 1.15A). Do not drive the chisel or push the saw through the sacrum into the rectum.
8. When finished with the laminectomy, you should see the posterior surface of the dura mater from vertebral levels C4 to S2.

SPINAL MENINGES

1. Observe the **epidural (extradural) space.** Use blunt dissection to remove the **epidural fat** and the **posterior internal vertebral venous plexus** from the epidural space. **[N 163]**

CLINICAL CORRELATION

Vertebral Venous Plexuses

The veins of the vertebral venous plexuses are valveless, permitting blood to flow superiorly or inferiorly depending on blood pressure gradients. The vertebral venous plexuses can serve as routes for metastasis of cancer from the pelvis to the vertebrae, vertebral canal, and cranial cavity.

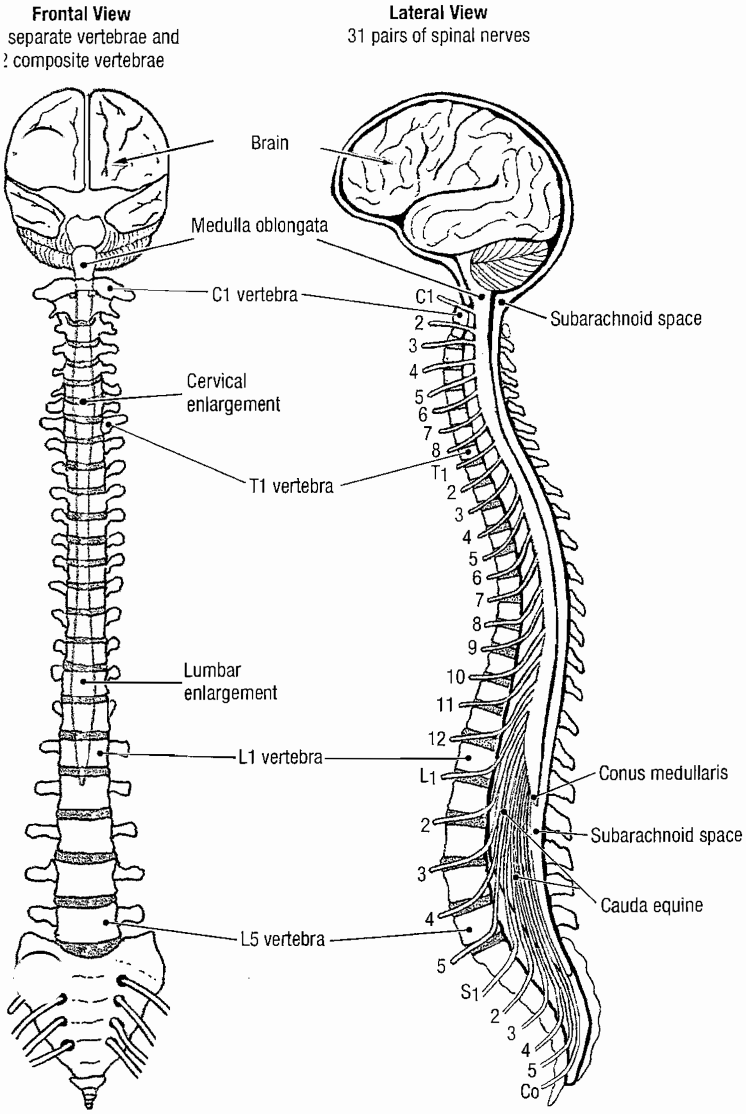


Figure 1.13. The spinal cord within the vertebral canal.

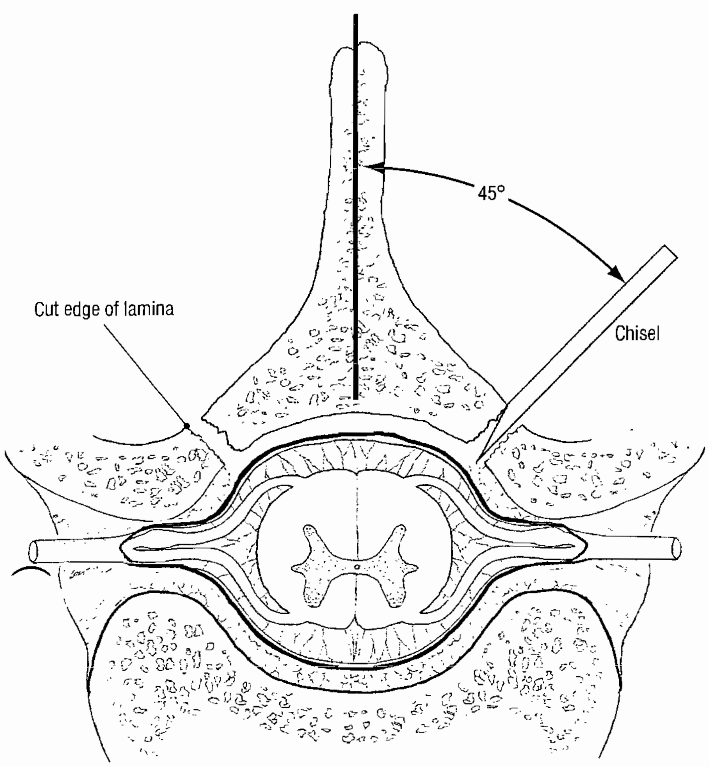


Figure 1.14. How to open the vertebral canal.

2. Identify the **dural sac**, which ends inferiorly at vertebral level S2 (Fig. 1.15A). **[G 324; R 221; C 430]**
3. In the thoracic region, lift a fold of **dura mater** with forceps and use scissors to cut a small opening in its dorsal midline. Use scissors to extend the cut superiorly as far as C4 and inferiorly to S2. Do this without damaging the underlying arachnoid mater. Retract the dura mater and pin it back.
4. Identify the **arachnoid mater** (Fig. 1.16). It is very delicate. Incise the arachnoid mater in the dorsal midline and observe the **subarachnoid space**. The subarachnoid space contains cerebrospinal fluid in the living person but not in the cadaver. **[G 325; N 162; C 431]**
5. Retract the arachnoid mater and observe the **spinal cord**. The spinal cord is completely invested by **pia mater**, which is on the surface of the spinal cord and cannot be dissected from it.
6. Identify the following features of the spinal cord: **[G 322; N 153; R 220; C 430]**
   - **Cervical enlargement** (spinal cord segments C4 to T1) provides nerves to the upper limb.
   - **Lumbar enlargement** (spinal cord segments L2 to S3) provides nerves to the lower limb.
   - **Conus medullaris (medullary cone)** is the end of the spinal cord located between vertebral levels L1 and L2.
   - **Cauda equina** (L., tail of horse) is a collection of ventral and dorsal roots in the lower vertebral canal (Fig. 1.15B).

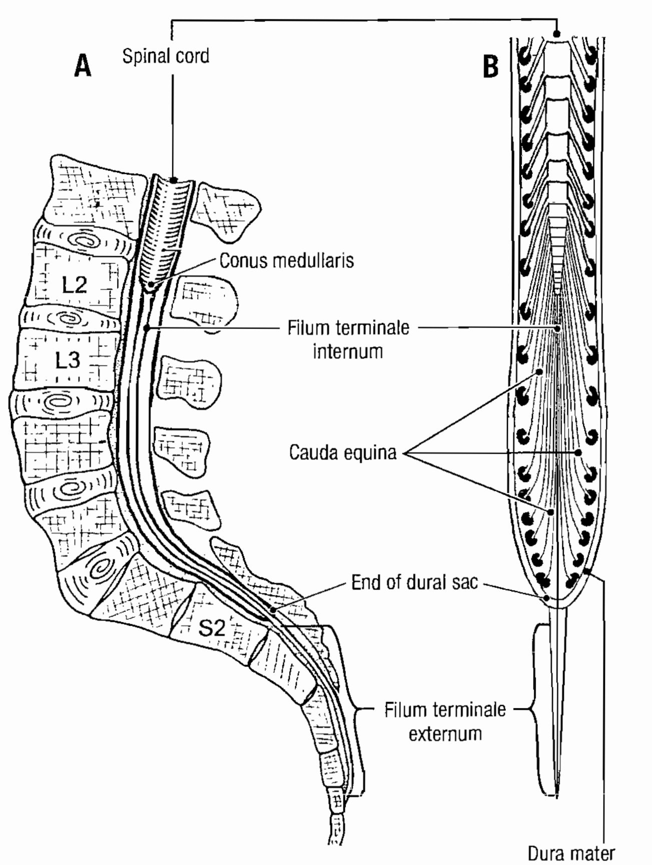


Figure 1.15. Lower portion of the vertebral canal and spinal cord. **A.** Lateral view. **B.** Posterior view.

- **Filum terminale internum** (Fig. 1.15A,B) is a delicate filament continuous with the pia mater. It arises from the inferior tip of the conus medullaris and ends at S2 where it is encircled by the lower end of the dural sac.
- **Filum terminale externum (coccygeal ligament)** (Fig. 1.15A,B) is the continuation of the filum terminale internum below vertebral level S2. The filum terminale externum passes through the sacral hiatus and ends by attaching to the coccyx.

7. The pia mater forms two **denticulate ligaments**, one on each side of the spinal cord (Fig. 1.16). Each denticulate ligament has 21 teeth and each tooth is attached to the inner surface of the dura mater, anchoring the spinal cord. **[G 327; N 162; R 221; C 431]**
8. Use a probe to follow **dorsal roots** and **ventral roots** to the point where they pierce the dura mater and enter the **intervertebral foramen** (Fig. 1.16). The dorsal roots are on the dorsal side of the denticulate ligament and the ventral roots are on the ventral side of the denticulate ligament. The spinal nerve will be formed outside of the vertebral canal by the joining of the dorsal and ventral roots.
9. Observe small **blood vessels** that course along the ventral and dorsal roots. These are branches of posterior intercostal, lumbar, or vertebral arteries, depending on vertebral level. They pass into the vertebral canal through the intervertebral foramen and supply the spinal cord. **[G 329; N 165; C 431]**
10. In the thoracic region, expose one **spinal nerve.** Place a probe into an intervertebral foramen to protect the nerve within it. Use bone forceps to remove the posterior wall of the intervertebral foramen and expose the **spinal ganglion** (dorsal root ganglion) (Fig. 1.16). Distal to the spinal ganglion, identify the spinal nerve and follow it distally to the point where it divides into a **dorsal primary ramus** and a **ventral primary ramus.**

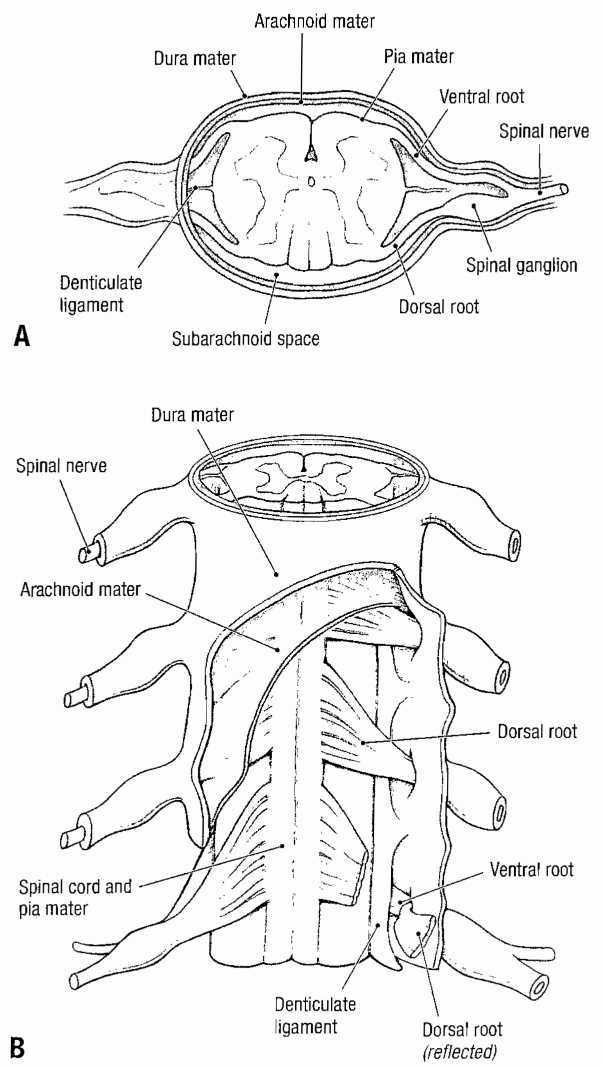


Figure 1.16. Relationships of the meninges to the spinal cord and nerve roots. **A.** Transverse section. **B.** Posterior view.

CLINICAL CORRELATION

Lumbar Puncture

Cerebrospinal fluid (CSF) can be obtained from the subarachnoid space inferior to the conus medullaris (Fig. 1.17). At this level, there is no danger of penetrating the spinal cord with the puncture needle.

After you dissect . . .

Review the formation and branches of a typical spinal nerve. Describe the way that the deep back muscles receive their innervation. Review the coverings and parts of the spinal cord and study an illustration that shows the blood supply to the spinal cord. Consult a dermatome chart and relate this pattern of cutaneous innervation to the spinal cord segments. **[G 331; N 157; C 404]**

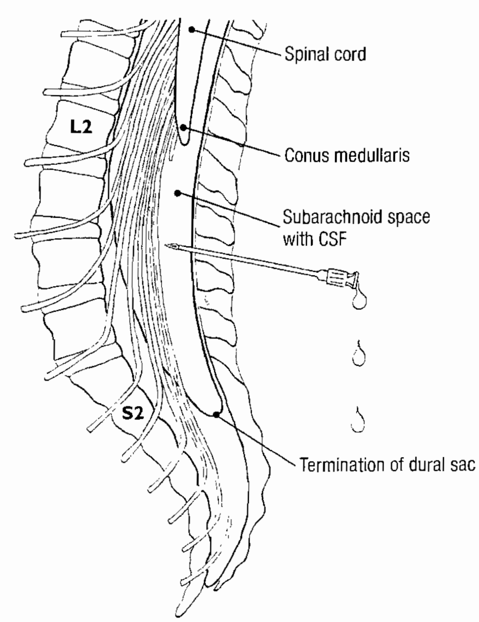


Figure 1.17. Lumbar puncture for removal of cerebrospinal fluid.

CHAPTER 2

THE UPPER LIMB

The function of the upper limb is to place the hand in position to be effective as a grasping tool. As such, the upper limb has adapted into a body part with great freedom of motion. Muscles that control this motion extend across the back and thorax. If the back has previously been dissected, the superficial group of back muscles has been studied. If the thorax has previously been dissected, the pectoral region has been studied. If the upper limb is your first dissection unit, you will be instructed to dissect the superficial group of back muscles and the pectoral region at the appropriate time.

SURFACE ANATOMY [G 465, 475; N 401; C 26]

The upper limb is divided into four regions: **shoulder, arm (brachium), forearm (antebrachium),** and **hand (manus).** The surface anatomy of the upper limb can be studied on a living subject or on the cadaver. Place the cadaver in the supine position (face up) and palpate the following superficial structures (Fig. 2.01):

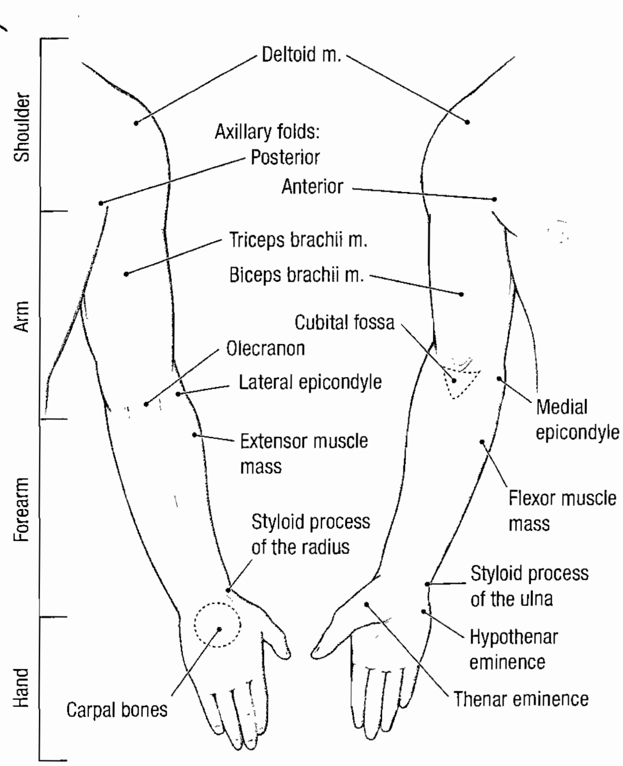


Figure 2.01. Surface anatomy of the upper limb.

- **Anterior axillary fold**
- **Posterior axillary fold**
- **Deltoid muscle**
- **Biceps brachii muscle**
- **Triceps brachii muscle**
- **Cubital fossa**
- **Medial epicondyle**
- **Lateral epicondyle**
- **Olecranon**
- **Flexor muscle mass (in the forearm)**
- **Extensor muscle mass (in the forearm)**
- **Carpal bones (on the dorsum of the wrist)**
- **Styloid process of the radius**
- **Styloid process of the ulna**
- **Thenar eminence**
- **Hypothenar eminence**

SUPERFICIAL VEINS AND CUTANEOUS NERVES

Before you dissect . . .

The **superficial fascia** of the upper limb contains fat, **superficial veins,** and **cutaneous nerves.** In the living body, the superficial veins may be conspicuous through the skin. They are frequently used for drawing blood and injecting medications. In the cadaver, the superficial veins are not conspicuous through the skin. The cutaneous nerves of the upper limb pierce the deep fascia to reach the superficial fascia and skin.

The order of dissection will be as follows: the entire upper limb will be skinned. The objective is to remove only the skin, leaving the superficial fascia undisturbed. The superficial veins and selected cutaneous nerves will be dissected. The fat will then be removed so that the deep fascia may be observed. **[G 462, 464; N 462, 463; R 388, 394; C 25]**

Dissection Instructions

SKIN INCISIONS

1. If the back has not been dissected previously, go to page 7, follow the skinning instructions that are provided there, and return to this page.
2. If the thorax has not been dissected previously, go to page 43, follow the skinning instructions that are provided there, and return to this page.
3. Place the cadaver in the supine position (face up).
4. Refer to Figure 2.02. Before cutting, realize that the skin is thin on the anterior surface of the upper limb. *Be careful not to cut too deeply.*

KEY TO REFERENCES
G = Grant's Atlas, 11th ed., page number
N = Netter's Atlas, 3rd ed., plate number
R = Rohen's Color Atlas of Anatomy, 5th ed., page number
C = Clemente's Atlas, 4th ed., page number

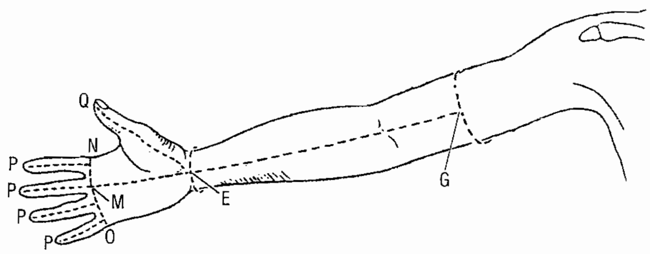


Figure 2.02. Skin incisions.

5. Use a scalpel to make an incision that encircles the arm midway between the shoulder and the elbow (G). If the back has been skinned, this incision has been made previously.
6. Make an incision that encircles the wrist (E). The skin is very thin (2 mm) on the anterior surface of the wrist.
7. Join the two circular incisions with a longitudinal incision on the anterior aspect of the upper limb (E to G).
8. Remove the skin from the arm and forearm and place it in the tissue container. Do not damage the superficial veins and cutaneous nerves in the superficial fascia.
9. Force open the clenched hand and let your dissection partner hold it open.
10. Make a longitudinal incision across the palm (E to M).
11. Make a transverse incision at the level of the webs of the fingers (N to O).
12. Make a longitudinal incision on the anterior surface of digits 2 to 5 (from incision N/O to P).
13. Make a longitudinal incision along the palmar surface of digit 1 (E to Q).
14. Remove the skin from the palmar and dorsal surfaces of the hand and digits 1 to 5. *When skinning the digits, proceed with caution.* Note that the subcutaneous tissue on the palmar surface of the digits is very thin, especially at the skin creases. There are digital nerves, vessels, and fibrous digital sheaths immediately deep to the skin.

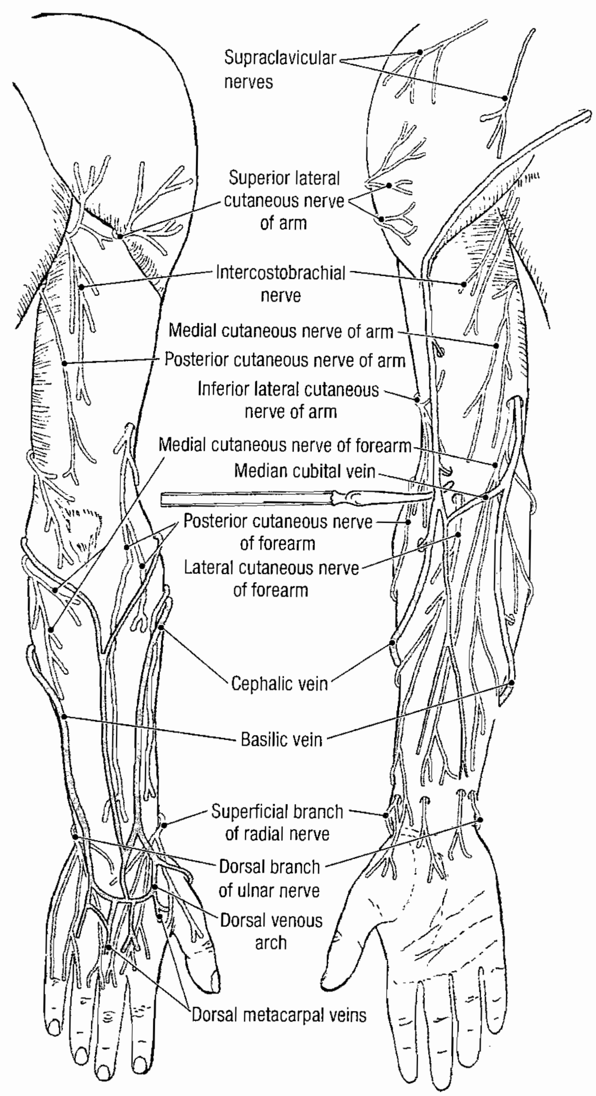


Figure 2.03. Cutaneous nerves and superficial veins.

SUPERFICIAL VEINS [G 464; N 462, 463; R 386; C 25]

1. Use blunt dissection to demonstrate the superficial veins (Fig. 2.03).
2. On the dorsum of the hand, identify the **dorsal venous arch**. Note that the dorsal venous arch collects venous drainage from the posterior surface of the hand and digits.
3. In the posterior forearm, demonstrate the **basilic vein** and **cephalic vein**, which arise from the dorsal venous arch.
4. Abduct the upper limb and have your dissection partner hold it in the abducted position.
5. Use a probe to follow the cephalic and basilic veins proximally, freeing them from the surrounding fat and connective tissue.
6. Demonstrate that the cephalic and basilic veins are joined across the cubital fossa by the **median cubital vein**. This pattern can be quite variable and should be observed on other cadavers.
7. Follow the cephalic vein proximally into the pectoral region where it courses in the **deltopectoral groove** between the deltoid muscle and the pectoralis major muscle. Near the clavicle, the cephalic vein passes deeply into the **deltopectoral triangle** to join the axillary vein.
8. Follow the basilic vein proximally. Before reaching the axilla, it pierces the deep fascia to join the brachial vein.
9. Use a probe to elevate the superficial veins (Fig. 2.03). Note that **perforating veins** penetrate the deep fascia and connect the superficial veins to deep veins.

CUTANEOUS NERVES [G 462; N 462, 463; R 388; C 25]

1. Do not dissect all of the cutaneous nerves of the upper limb. A few (described later in greater detail) are clinically relevant and should be demonstrated by blunt

dissection. Before dissecting, use an illustration to familiarize yourself with the course and distribution of all of the **cutaneous nerves of the upper limb** (Fig. 2.03):

- **Superior lateral cutaneous nerve of the arm**
- **Inferior lateral cutaneous nerve of the arm**
- **Posterior cutaneous nerve of the arm**
- **Intercostobrachial nerve**
- **Medial cutaneous nerve of the arm**
- **Medial cutaneous nerve of the forearm**
- **Lateral cutaneous nerve of the forearm**
- **Posterior cutaneous nerve of the forearm**

2. At the level of the elbow, identify the **lateral cutaneous nerve of the forearm**. It is located in the superficial fascia lateral to the biceps brachii tendon and in close relationship to the cephalic vein or the median cubital vein.
3. At the level of the elbow, identify the **medial cutaneous nerve of the forearm**. It is located on the medial side of the biceps brachii tendon and is in close relationship to the basilic vein.
4. At the lateral side of the wrist, use a probe to dissect the **superficial branch of the radial nerve**. The superficial branch of the radial nerve may be found in the superficial fascia near the styloid process of the radius. Expose only 2 or 3 cm of this nerve.
5. At the medial side of the wrist, identify the **dorsal branch of the ulnar nerve.** The dorsal branch of the ulnar nerve may be found in the superficial fascia near the styloid process of the ulna. Expose only 2 or 3 cm of this nerve.
6. The cutaneous nerves to the digits will be studied with the hand.
7. Remove all remaining superficial fascia, preserving the superficial veins and nerves that you have dissected. Do not disturb the deep fascia. Place the superficial fascia in the tissue container.
8. Examine the **deep fascia** of the upper limb. Note that the deep fascia of the upper limb extends from the shoulder to the fingertips. It attaches to the bones of the upper limb and forms compartments that contain groups of muscles. The deep fascia of the upper limb is regionally named: **brachial fascia** in the arm, **antebrachial fascia** in the forearm, and **palmar fascia** and **dorsal fascia of the hand** in the hand.

After you dissect . . .

Review the superficial fascia of the upper limb. Use the dissected specimen to trace the course of the superficial veins from distal to proximal. Review the location of the cephalic vein, basilic , and median cubital vein in the cubital fossa and recall that these are important for venipuncture. Use the dissected specimen to review the four cutaneous nerves that you have dissected. Use an illustration to review the pattern of distribution of the cutaneous nerves that you did not dissect. Compare this pattern of cutaneous nerve distribution to a dermatome chart. Review the deep fascia of the upper limb and name its parts. **[G 462, 463;**

SUPERFICIAL GROUP OF BACK MUSCLES

Instructions for dissection of the superficial group of back muscles are found in Chapter 1, *The Back*. If you are dissecting the upper limb before the back, the superficial group of back muscles must be dissected now. Turn to pages 7–9, complete that dissection, and return to this page.

SCAPULAR REGION

Before you dissect . . .

There are six shoulder (scapulohumeral) muscles: **Deltoid, supraspinatus, infraspinatus, teres minor, teres major,** and **subscapularis.** The order of dissection will be as follows: the deltoid muscle will be studied, then it will be detached from its proximal attachment and the course of its nerve and artery will be studied. Subsequently, the four muscles arising from the dorsal surface of the scapula (supraspinatus, infraspinatus, teres major, teres minor) will be dissected and their nerves and blood vessels will be demonstrated. The subscapularis muscle will be dissected with the axilla.

SKELETON OF THE SCAPULAR REGION [G 498; N 404; R 359, 361; C 70, 76]

Refer to a skeleton. On the **scapula**, identify (Fig. 2.04):

- **Acromion**
- **Spine**
- **Supraspinous fossa**
- **Suprascapular notch**
- **Infraspinous fossa**
- **Supraglenoid tubercle**
- **Glenoid cavity**
- **Infraglenoid tubercle**
- **Coracoid process**

On the **humerus**, identify (Fig. 2.04):

- **Head**
- **Anatomical neck**
- **Greater tubercle**
- **Lesser tubercle**
- **Intertubercular sulcus (bicipital groove)**
- **Surgical neck**
- **Deltoid tuberosity**
- **Radial groove**

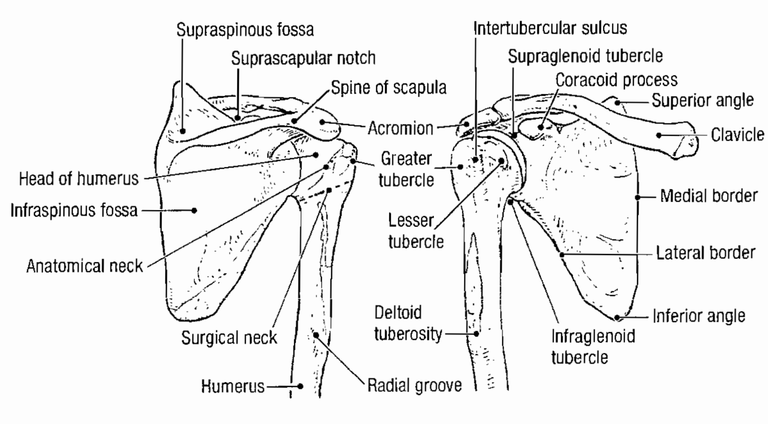


Figure 2.04. Skeleton of the scapular region.

Dissection Instructions

1. Place the cadaver in the prone position (face down). Abduct the upper limb to 45 degrees. If a block is available, place it under the chest.
2. Use blunt dissection to define the borders of the **deltoid muscle**. The proximal attachments of the deltoid muscle are the spine of the scapula, the acromion of the scapula, and the lateral one-third of the clavicle. The distal attachment of the deltoid muscle is the deltoid tuberosity of the humerus. The deltoid muscle abducts the humerus. **[G 497; N 407; R 370; C 407]**
3. Use a scalpel to detach the deltoid muscle from its proximal attachments. Make your cuts close to the bone. Leave the muscle attached to the humerus. Reflect the deltoid muscle laterally, taking care not to tear the vessels and nerve that course along its deep surface.
4. Observe the **axillary nerve** and the **posterior circumflex humeral artery and vein** on the deep surface of the deltoid muscle near its attachment to the humerus. Use a probe to clean the nerve and vessels and trace them around the surgical neck of the humerus (Fig. 2.05). **[G 506; N 409; R 371; C 41]**
5. Note that the axillary nerve innervates the deltoid muscle and the **teres minor muscle.**
6. Follow the axillary nerve and the posterior circumflex humeral artery and vein proximally. Push your finger parallel to the nerve and vessels to open the **quadrangular space** (Fig. 2.05). Define the **borders of the quadrangular space**:
   - **Superior border**—inferior border of the teres minor muscle
   - **Lateral border** – surgical neck of the humerus
   - **Medial border** – long head of the triceps brachii muscle
   - **Inferior border** – superior border of the teres major muscle
7. Identify the **long head of the triceps brachii muscle.** Observe that the long head of the triceps brachii muscle passes anterior to the teres minor muscle and posterior to the teres major muscle.
8. Use a probe to clean and define the borders of the **teres minor muscle.** The proximal attachment of the teres minor muscle is the lateral border of the scapula. The distal attachment of the teres minor muscle is the inferior facet of the greater tubercle of the humerus. The teres minor muscle laterally rotates the humerus.
9. Clean and define the borders of the **teres major muscle.** The proximal attachment of the teres major muscle is the inferior angle of the scapula. The distal attachment of the teres major muscle is the medial lip of the intertubercular sulcus of the humerus. The teres major muscle adducts and medially rotates the humerus.
10. Reflect the trapezius muscle superiorly, leaving it attached along the "hinge" of cervical fascia that was created during the back dissection.
11. Clean and define the borders of the **supraspinatus muscle.** The proximal attachment of the supraspinatus muscle is the supraspinous fossa of the scapula. The distal attachment of the supraspinatus muscle is the highest facet of the greater tubercle of the humerus. The supraspinatus muscle initiates abduction of the humerus.

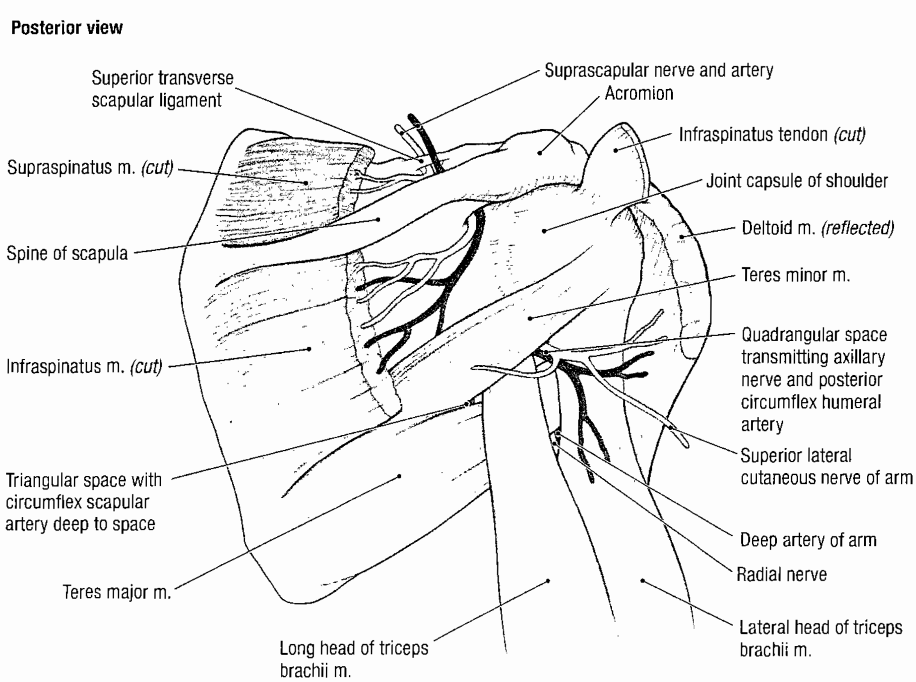


Figure 2.05. Blood and nerve supply to the posterior aspect of the shoulder.

12. Use a probe to define the borders of the **infraspinatus muscle**. The proximal attachment of the infraspinatus muscle is the infraspinous fossa of the scapula. The distal attachment of the infraspinatus muscle is the middle facet of the greater tubercle of the humerus. The infraspinatus muscle laterally rotates the humerus.
13. The **suprascapular artery** and the **suprascapular nerve** are found deep to the supraspinatus muscle (Fig. 2.05). The supraspinatus muscle must be reflected to see them. **[G 506; N 409; R 392; C 23]**
14. Use a scalpel to transect the supraspinatus muscle approximately 5 cm lateral to the superior angle of the scapula but medial to the suprascapular notch. Hold a disarticulated scapula over the scapula of the cadaver to help locate the proper level of the cut.
15. Use blunt dissection to free the distal portion of the supraspinatus muscle from the supraspinous fossa. Reflect the distal part of the supraspinatus muscle laterally. Leave it attached to the humerus.
16. Clean the **suprascapular artery and nerve**. Follow the artery and nerve superiorly. Observe that the suprascapular artery passes superior to the **superior transverse scapular ligament** and the suprascapular nerve passes inferior to it (Fig. 2.05). This relationship can be remembered by use of a mnemonic device: "*A*rmy (*a*rtery) goes over the bridge, *N*avy (*n*erve) goes under the bridge."
17. Transect the **infraspinatus muscle** approximately 5 cm lateral to the vertebral border of the scapula (Fig. 2.05).
18. Use blunt dissection to loosen the distal portion of the infraspinatus muscle from the scapula and reflect it laterally.
19. Follow the **suprascapular artery** and the **suprascapular nerve** inferiorly. Note that they reach the infraspinatus muscle by coursing deep (anterior) to the spine of the scapula (Fig. 2.05).
20. The suprascapular artery contributes to the collateral circulation of the scapular region. Use an illustration to study the **scapular anastomosis. [G 471; N 410; R 392]**
21. The four muscles of the **rotator cuff** are: **supraspinatus, infraspinatus, teres minor, and subscapularis**. The subscapularis muscle will be dissected with the axilla. Use an illustration to study the distal attachments of the rotator cuff muscles. **[G 498, 514; N 403, 404; R 371; C 37]**

After you dissect . . .

Replace the muscles of the scapular region in their correct anatomical positions. Use an illustration and the dissected specimen to review the proximal attachment and distal attachment of each muscle of the scapular region. List the action of each muscle and the combined action of the rotator cuff group of muscles. Review the origin, course, and distribution of the transverse cervical artery, dorsal scapular artery, and suprascapular artery. Review the scapular anastomosis. Review the relationship of the suprascapular artery and the suprascapular nerve to the superior transverse scapular ligament. Review the innervation of each

PECTORAL REGION

Instructions for dissection of the pectoral region are found in Chapter 3, *The Thorax*. If you are dissecting the upper limb before the thorax, the pectoral region must be dissected now. Turn to pages 43–46, complete that dissection, and return to this page.

AXILLA

Before you dissect . . .

The **axilla** is the region between the pectoral muscles, the scapula, the arm, and the thoracic wall (Fig. 2.06). It is a transitional region through which vessels and nerves pass from the root of the neck into the upper limb. The **contents of the axilla** are: **axillary sheath, brachial plexus, axillary vessels and their branches, lymph nodes and lymphatic vessels, portions of three muscles,** and a considerable amount of fat and connective tissue.

Study a diagram and note the following **boundaries of the axilla: [G 482; N 411]**

- **Apex of the axilla –** bounded by the clavicle anteriorly, the upper border of the scapula posteriorly and the first rib medially
- **Base of the axilla –** skin and fascia of the armpit
- **Anterior wall –** pectoralis major muscle, pectoralis minor muscle, and the clavipectoral fascia
- **Posterior wall –** posterior axillary fold (teres major and latissimus dorsi muscles) and the subscapularis muscle that covers the anterior surface of the scapula
- **Medial wall –** upper portion of the thoracic wall and the serratus anterior muscle, which overlies this wall
- **Lateral wall –** intertubercular sulcus of the humerus

The order of dissection will be as follows: the pectoralis major and pectoralis minor muscles will be reflected to expose the contents of the axilla. The axillary vein and its tributaries will be removed. The branches of the axillary artery will be dissected. The brachial plexus will be studied.

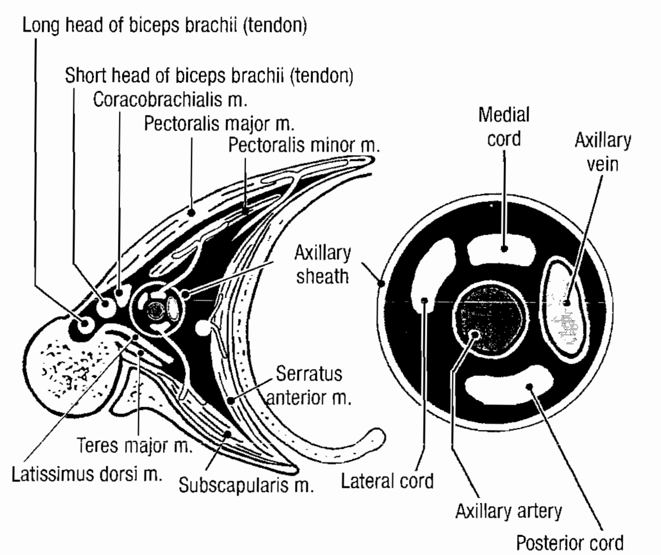


Figure 2.06 Walls and contents of the axilla (transverse section).

Dissection Instructions

1. Review the pectoralis major muscle, the pectoralis minor muscle, and the clavipectoral fascia.
2. Reflect the pectoralis major muscle laterally.
3. Reflect the pectoralis minor muscle superiorly.
4. Abduct the arm to approximately 45 degrees.
5. Identify the **axillary sheath** (Fig. 2.06). The axillary sheath is a connective tissue structure that surrounds the axillary vessels and brachial plexus. The axillary sheath extends from the lateral border of the first rib to the inferior border of the teres major muscle.
6. Use scissors to open the anterior surface of the axillary sheath.
7. Identify the **axillary vein** within the axillary sheath. Cut the cephalic vein where it joins the axillary vein and preserve it. Use a probe to dissect the axillary vein from the structures that lie posterior to it (axillary artery and brachial plexus). Cut the axillary vein at the lateral border of the first rib and bluntly dissect it distally as far as possible. Remove it completely. **[G 481; N 412; R 397; C 15]**
8. As the dissection proceeds, remove veins that are tributary to the axillary vein. Retain the accompanying arteries. Note the presence of lymph nodes that are associated with the veins.

AXILLARY ARTERY [G 488, 489; N 410; R 398; C 14]

The **axillary artery** begins at the lateral border of the first rib, where it is the continuation of the **subclavian artery** (Fig. 2.07). The axillary artery ends at the inferior border of the teres major muscle, where its name changes to **brachial artery**. The axillary artery is surrounded by the brachial plexus (Fig. 2.06, inset). *The brachial plexus must be retracted and preserved during dissection of the axillary artery and its branches.*

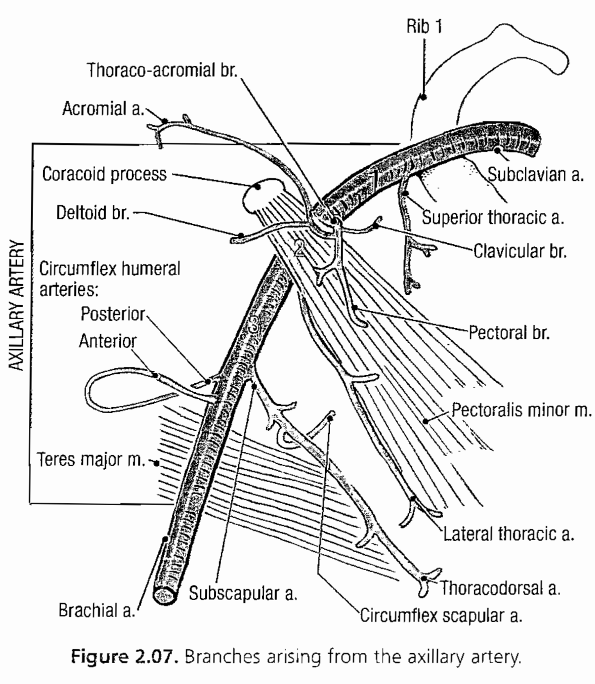


Figure 2.07. Branches arising from the axillary artery.

1. Identify the **three parts of the axillary artery** (Fig. 2.07):
   - **First part** extends from the lateral border of the first rib to the medial border of the pectoralis minor muscle.
   - **Second part** lies posterior to the pectoralis minor muscle.
   - **Third part** extends from the lateral border of the pectoralis minor muscle to the inferior border of the teres major muscle.

Dissection note: The branching pattern of the axillary artery may vary from that which is commonly illustrated. If the pattern is different in your specimen, note that the branches are named according to their distribution rather than by their origin.

2. The first part of the axillary artery has one branch, the **superior thoracic artery**. Follow the superior thoracic artery to its area of distribution in the first and second intercostal spaces.
3. The second part of the axillary artery has two branches (Fig. 2.07): **thoraco-acromial artery** and **lateral thoracic artery**.
4. Use blunt dissection to open the clavipectoral fascia and identify the thoraco-acromial artery on the medial side of the pectoralis minor muscle.
5. Identify the branches of the thoraco-acromial artery:
   - **Acromial branch** – passes laterally across the coracoid process to the acromion.
   - **Deltoid branch** – courses laterally in the deltopectoral groove. It accompanies the cephalic vein.
   - **Pectoral branch** – passes between the pectoralis major and pectoralis minor muscles and supplies both.
   - **Clavicular branch** – courses superior and medial to supply the subclavius muscle.
6. Identify the **lateral thoracic artery** and follow it along the lateral border of the pectoralis minor muscle (Fig. 2.07). The lateral thoracic artery may have an alternate origin from the subscapular artery, but it consistently courses along the lateral border of the pectoralis minor muscle. The lateral thoracic artery supplies the pectoral muscles and the lateral thoracic wall. In females, the lateral thoracic artery also supplies the lateral portion of the mammary gland.
7. The third part of the axillary artery has three branches: **subscapular artery, posterior circumflex humeral artery**, and **anterior circumflex humeral artery**.
8. Identify the **subscapular artery**. It is the largest branch of the axillary artery. The subscapular artery courses inferiorly for a short distance before dividing into the **circumflex scapular artery** (to muscles on the posterior surface of the scapula) and the **thoracodorsal artery** (to the latissimus dorsi muscle). The subscapular artery gives off several unnamed muscular branches.
9. Find the **anterior and posterior circumflex humeral arteries**, which arise from the axillary artery distal to the origin of the subscapular artery. Occasionally,

these two arteries may arise from a short common trunk. They supply the deltoid muscle.

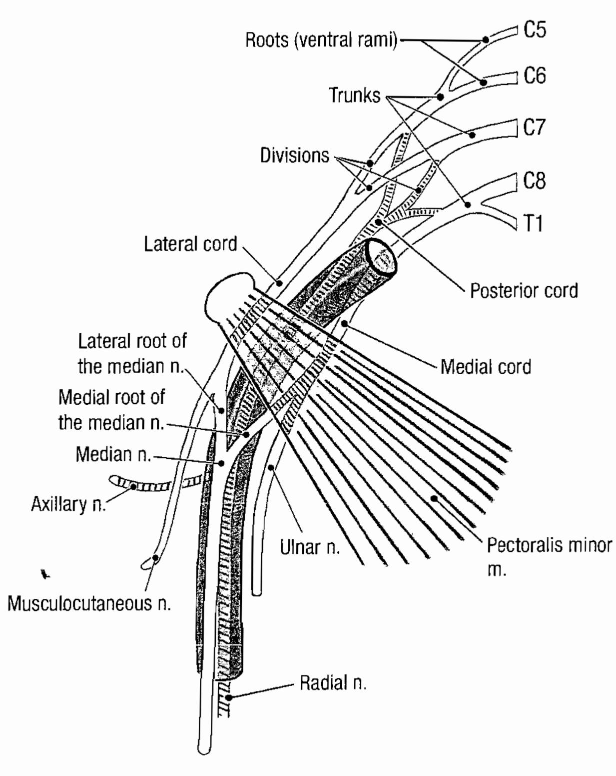
10. Observe that the **posterior circumflex humeral artery** is the larger of the two circumflex humeral arteries. Follow it as it passes posterior to the surgical neck of the humerus with the axillary nerve. Demonstrate that the posterior circumflex humeral artery and the axillary nerve pass through the quadrangular space.
11. The **anterior circumflex humeral artery** courses around the anterior surface of the humerus at the surgical neck. It passes deep to the tendon of the long head of the biceps brachii muscle.

BRACHIAL PLEXUS [G 488; N 412; R 399; C 15]

The brachial plexus begins in the root of the neck superior to the clavicle. It passes distally toward the base of the axilla, where its **terminal branches** arise. Only the **infraclavicular part of the brachial plexus** will be dissected at this time. The **supraclavicular part** will be dissected with the neck.

The **three cords of the brachial plexus** (lateral, medial, and posterior) are named according to their relationship to the second part of the axillary artery (posterior to the pectoralis minor muscle) (Fig. 2.08).

1. Identify the **musculocutaneous nerve**. It is the most lateral terminal branch of the brachial plexus and enters the coracobrachialis muscle.
2. To find the **lateral cord**, use your fingers to follow the musculocutaneous nerve proximally.
3. Observe that the lateral cord gives rise to one other large branch, the **lateral root of the median nerve**. Follow the lateral root distally and identify the **median nerve.**



4. To find the **medial cord**, trace the **medial root of the median nerve** proximally.
5. The medial cord continues distally as the **ulnar nerve**.
6. Note that the three **terminal branches** that you have just identified (musculocutaneous nerve, median nerve, and ulnar nerve) form the letter *M* anterior to the third part of the axillary artery (Fig. 2.08).
7. Trace the **medial** and **lateral pectoral nerves** from the reflected pectoral muscles to their origins from the medial and lateral cords, respectively.
8. Identify two branches of the medial cord. They are the **medial cutaneous nerve of the forearm** and the **medial cutaneous nerve of the arm**. Use your fingers to trace these nerves a short distance (7.5 cm) into the arm.
9. Use a piece of string to retract the axillary artery, the lateral cord, and the medial cord in the superior direction. This procedure exposes the **posterior cord** of the brachial plexus. The branches of the posterior cord are the **axillary nerve**, **radial nerve**, and three **subscapular nerves** (upper, middle and lower).
10. Use blunt dissection to clean the **axillary nerve**. Observe that the axillary nerve passes posterior to the humerus and courses through the quadrangular space with the posterior circumflex humeral artery (Fig. 2.09).
11. Use blunt dissection to clean the **radial nerve** and confirm that it leaves the axilla by passing posterior to the humerus. The radial nerve is the motor and sensory nerve to the posterior portion of the upper limb.
12. Identify the subscapular nerves that arise from the posterior cord (Fig. 2.09). The **upper subscapular nerve** innervates the subscapularis muscle. The **middle subscapular nerve (thoracodorsal nerve)** innervates the latissimus dorsi muscle. The **lower subscapular nerve** innervates the subscapularis muscle and the teres major muscle. Verify that these nerves run in the loose connective tissue on the anterior surface of the subscapularis muscle.

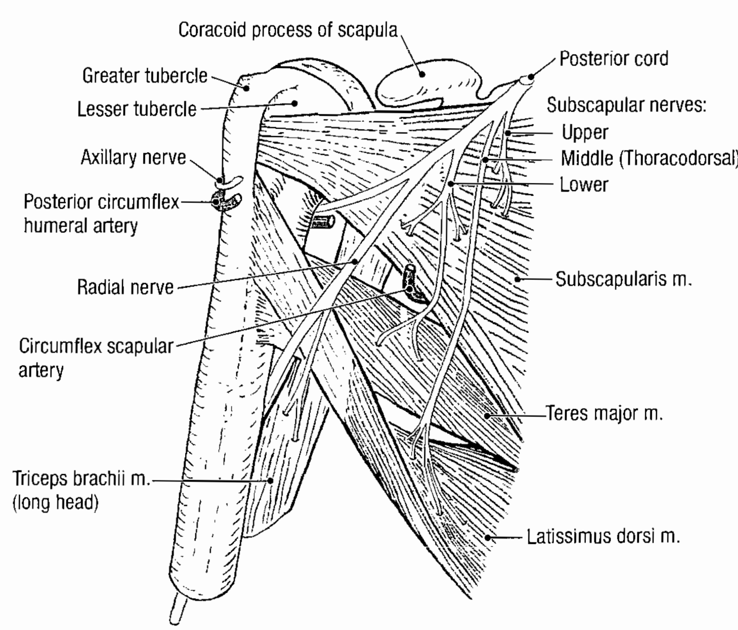


Figure 2.09. Posterior wall of the axilla and posterior cord of the brachial plexus

13. Identify the three muscles that form the posterior wall of the axilla: **latissimus dorsi**, **teres major**, and **subscapularis** (Fig. 2.09).
14. Examine the **subscapularis muscle**. The proximal attachment of the subscapularis muscle is the subscapular fossa of the scapula. The distal attachment of the subscapularis muscle is the lesser tubercle of the humerus. The subscapularis muscle medially rotates the humerus. The subscapularis muscle is a member of the **rotator cuff group of muscles**.
15. Verify that the medial wall of the axilla is formed by the **serratus anterior muscle** (Fig. 2.06). Use an illustration to study the attachments of the serratus anterior muscle. The proximal attachments of the serratus anterior muscle are the external surfaces of ribs 1 to 8. Its distal attachment is the anterior surface of the medial border of the scapula. The serratus anterior muscle protracts the scapula. The serratus anterior muscle also rotates the scapula, especially when the arm is abducted above the horizontal plane. **[G 491; N 412; R 398; C 12]**
16. Use your fingers to follow the serratus anterior muscle posteriorly toward the medial margin of the scapula. On the superficial surface of this muscle, use a probe to free the **long thoracic nerve**. Note the vertical course of this nerve. Observe its branches to the serratus anterior muscle. Follow the nerve superiorly as far as possible toward the apex of the axilla.

CLINICAL CORRELATION

Nerve Injuries

The **long thoracic nerve** is vulnerable to stab wounds and to surgical injury during radical mastectomy. Injury of the long thoracic nerve affects the serratus anterior muscle. When a patient with paralysis of the serratus anterior muscle is asked to push with both hands against a wall, the medial border of the scapula protrudes on the affected side, a condition known as "winged scapula."

The **thoracodorsal nerve** is vulnerable to compression injuries and surgical trauma during mastectomy. Injury of the thoracodorsal nerve affects the latissimus dorsi muscle, resulting in a weakened ability to extend, adduct, and medially rotate the humerus.

The **axillary nerve** courses around the surgical neck of the humerus and may be injured during a fracture or during an inferior dislocation of the shoulder joint. Injury of the axillary nerve affects the deltoid muscle and teres minor muscle, resulting in a weakened ability to abduct and laterally rotate the humerus.

After you dissect . . .

Replace the pectoralis major muscle and the pectoralis minor muscle into their correct anatomical positions and review their attachments. Review the boundaries of the axilla. Use the dissected specimen to observe the relationship of the three parts of the axillary artery to the pectoralis minor muscle. Name all of the branches of the axillary artery and identify each branch on your dissected specimen. Test your understanding of the brachial plexus by drawing a picture that shows its structure and branches. Extend this exercise to the cadaver by demonstrating the divisions, cords, and terminal branches of the infraclavicular portion of the brachial plexus. Review the motor nerve supply to the muscles of the scapular region. Name each muscle and the nerve that supplies it. Realize that some of these nerves arise from the supraclavicular portion of the brachial plexus and that they have not yet been dissected completely. Review the movements of the scapula. Examine other cadavers to gain an appreciation of variations in the branching patterns of arteries and nerves. Use an illustration to review the lymphatic drainage of the axilla.

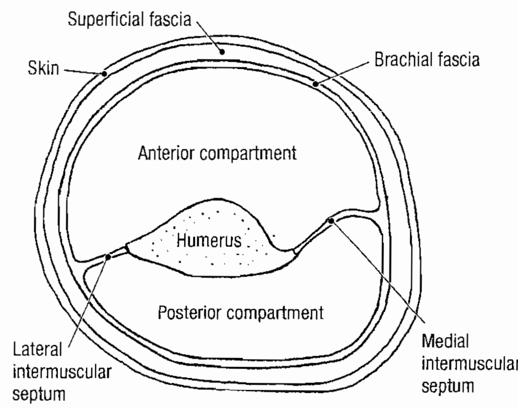


Figure 2.10. Compartments of the right arm.

ARM AND CUBITAL FOSSA

Before you dissect . . .

The **brachial fascia (deep fascia of the arm)** is a sleeve of tough connective tissue that is continuous at its proximal end with the **pectoral fascia**, the **axillary fascia**, and the deep fascia that covers the deltoid and latissimus dorsi muscles. Distally, the brachial fascia is continuous with the **antebrachial fascia (deep fascia of the forearm)**. The brachial fascia is connected to the medial and lateral sides of the humerus by intermuscular septa (Fig. 2.10), creating an **anterior (flexor) compartment** and a **posterior (extensor) compartment** for the muscles of the arm. The anterior compartment contains three muscles (biceps brachii, brachialis, and coracobrachialis) and the musculocutaneous nerve. The posterior compartment contains two muscles (triceps brachii and anconeus), the radial nerve, and the deep artery and vein of the arm.

The order of dissection will be as follows: the anterior compartment of the arm will be opened and its contents will be studied. Nerves and blood vessels will then be traced distally through the arm to the elbow region. The cadaver will be turned to the prone position to complete the dissection of the posterior compartment of the arm.

SKELETON OF THE ARM AND CUBITAL REGION [G 524; N 419; R 361, 362; C 76, 77]

Refer to a skeleton. On the **humerus** identify (Fig. 2.11):

- **Medial epicondyle**
- **Lateral epicondyle**
- **Olecranon fossa**

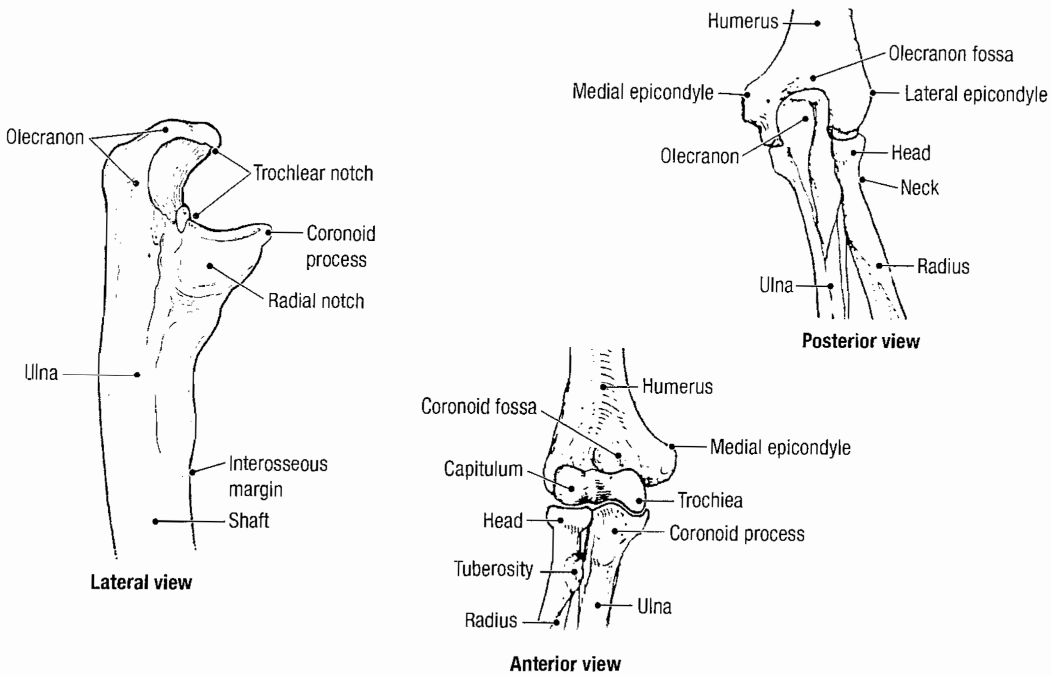


Figure 2.11. Skeleton of the elbow region.

On the **radius** identify:

- **Head**
- **Neck**
- **Tuberosity**

On the **ulna** identify:

- **Olecranon**

Dissection Instructions

ANTERIOR COMPARTMENT OF THE ARM [G 501, 502; N 414; R 401; C 32, 33]

1. Place the cadaver in the supine position.
2. Use scissors to make a longitudinal incision in the anterior surface of the brachial fascia from the level of the pectoralis major tendon to the elbow.
3. Use your fingers to separate the brachial fascia from the underlying muscles. Work laterally and medially from the incision and note the presence of the **lateral intermuscular septum** and the **medial intermuscular septum**.
4. Use your fingers to separate the three muscles in the anterior compartment of the arm: **coracobrachialis**, **brachialis**, and **biceps brachii** (Fig. 2.12).
5. The **biceps brachii muscle** has two proximal attachments on the scapula:
   - **Short head of the biceps brachii muscle** attaches to the coracoid process of the scapula.
   - **Long head of the biceps brachii muscle** attaches to the supraglenoid tubercle of the scapula. The tendon of the **long head of the biceps brachii**

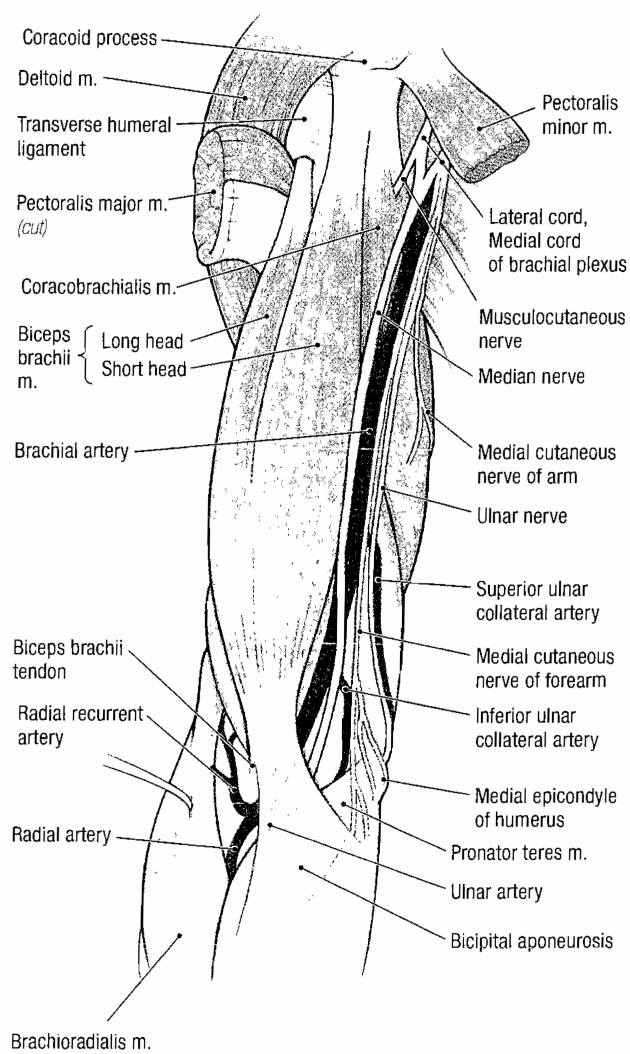


Figure 2.12. Contents of the anterior compartment of the arm.

muscle courses through the intertubercular sulcus of the humerus posterior to the **transverse humeral ligament**, and then enters the shoulder joint. Do not follow the tendon of the long head to its attachment on the scapula.

6. Identify the **biceps brachii tendon** at the level of the elbow. The distal attachment of the biceps brachii muscle is on the tuberosity of the radius. The biceps brachii muscle supinates and flexes the forearm.
7. Identify the **bicipital aponeurosis** (Fig. 2.12). The bicipital aponeurosis is a broad extension of the biceps tendon that attaches to the antebrachial fascia. The bicipital aponeurosis is located on the medial side of the biceps brachii tendon.
8. Find the **musculocutaneous nerve** in the axilla (Fig. 2.12). Follow the musculocutaneous nerve distally until it enters **coracobrachialis muscle**. Note that the musculocutaneous nerve innervates the three muscles of the anterior compartment of the arm.
9. Use your fingers to confirm that the proximal attachment of the coracobrachialis muscle is the coracoid process and that its distal attachment is on the medial side of the shaft of the humerus. The coracobrachialis muscle adducts and flexes the humerus.
10. Use scissors to transect the biceps brachii muscle approximately 5 cm proximal to the elbow. Preserve the musculocutaneous nerve. Reflect the two portions of the biceps brachii muscle proximally and distally, respectively.
11. Observe the **brachialis muscle**, which is deep to the biceps brachii muscle. The proximal attachment of the brachialis muscle is the anterior surface of the distal one-half of the humerus and its distal attachment is on the coronoid process of the ulna. The brachialis muscle flexes the forearm.
12. Follow the **musculocutaneous nerve** through the plane of loose connective tissue between the biceps brachii muscle and brachialis muscle.
13. After the musculocutaneous nerve gives off its muscular branches, it continues distally as the **lateral cutaneous nerve of the forearm**. Follow the lateral cutaneous nerve of the forearm to the cubital fossa, where it emerges near the lateral side of the biceps brachii tendon. Review the relationship of the lateral cutaneous nerve of the forearm to the cephalic vein.
14. Follow the **medial cutaneous nerve of the forearm** from the brachial plexus to the level of the elbow (Fig. 2.12). Note its relationship to the basilic vein at the level of the elbow.
15. Find the **median nerve** where it arises from the brachial plexus (Fig. 2.12). Use blunt dissection to follow the median nerve from the axilla to the cubital fossa. The median nerve courses distally within the **medial intermuscular septum** with the **brachial artery**.
16. Use blunt dissection to follow the **ulnar nerve** from the medial cord of the brachial plexus to the medial epicondyle of the humerus (Fig. 2.12). Note that the ulnar nerve is in contact with the posterior surface of the medial epicondyle of the humerus. Palpate the ulnar nerve on yourself where it passes posterior to the medial epicondyle.
17. Identify the **brachial artery**. The brachial artery is the continuation of the axillary artery. The brachial artery begins at the inferior border of the teres major muscle and ends at the level of the elbow by branching into the **ulnar artery** and **radial artery** (Fig. 2.12). Verify that the brachial artery courses with the median nerve within the medial intermuscular septum, and that the median nerve is the only large structure to cross the brachial artery. **[G 503; N 416; R 401; C 34, 35]**
18. The brachial artery has three named branches in the arm: **deep artery of the arm**, **superior ulnar collateral artery**, and **inferior ulnar collateral artery**. Several unnamed muscular branches also arise along the length of the brachial artery.
19. Remove the brachial veins and their tributaries to clear the dissection field. Preserve the branches of the brachial artery.
20. Find the **deep artery of the arm** (**deep brachial artery, profunda brachii artery**) where it arises from the brachial artery. The deep artery of the arm courses around the posterior surface of the humerus, where it accompanies the radial nerve in the radial groove. The course of the deep artery of the arm will be seen when the posterior compartment of the arm is dissected.
21. Identify the **superior ulnar collateral artery** (Fig. 2.12). It arises from the brachial artery near the middle of the arm. It courses distally with the ulnar nerve and passes posterior to the medial epicondyle of the humerus.
22. Find the **inferior ulnar collateral artery** (Fig. 2.12). It arises from the brachial artery approximately 3 cm above the medial epicondyle of the humerus and passes anterior to the medial epicondyle between the **brachialis muscle** and the **pronator teres muscle.**

CLINICAL CORRELATION

Brachial Artery [G 530; N 417; R 385; C 27]

Use an illustration to study the collateral circulation around the elbow joint (Fig. 2.13). The brachial artery may become blocked at any level distal to the deep artery of the arm without completely blocking blood flow to the forearm and hand.

In the arm, the brachial artery lies medial to the biceps brachii muscle and close to the shaft of the humerus. The brachial artery is compressed at this location when taking a blood pressure reading.

CUBITAL FOSSA [G 518-520; N 416; R 405-407; C 44, 48]

The **cubital fossa** (L. *cubitus*, elbow) is the depression on the anterior aspect of the elbow. The cubital fossa is clinically important because it contains superficial veins that are used for venipuncture. Large nerves and vessels pass through this region to enter the forearm.

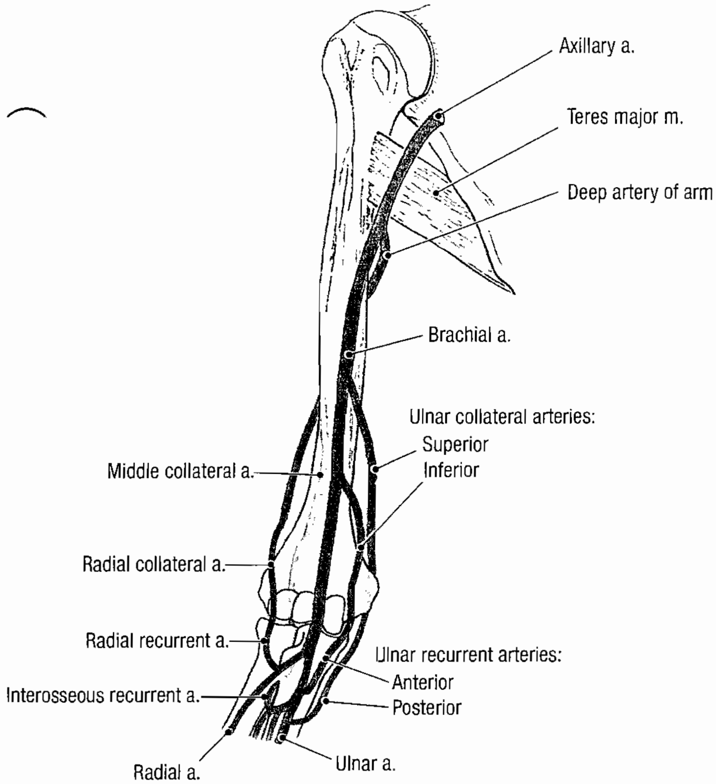


Figure 2.13. Brachial artery and its branches.

1. Note the **boundaries of the cubital fossa**:
   - **Lateral boundary** – brachioradialis muscle
   - **Medial boundary** – pronator teres muscle
   - **Superior boundary** – an imaginary line connecting the medial and lateral epicondyles of the humerus
   - **Superficial boundary (roof of the cubital fossa)** – antebrachial fascia reinforced by the bicipital aponeurosis
   - **Deep boundary (floor of the cubital fossa)** – brachialis and supinator muscles
2. Review the positions of the cephalic vein, basilic vein, and median cubital vein in the cubital fossa. To gain access to deeper structures, it may be necessary to cut the median cubital vein and retract its halves medially and laterally, respectively.
3. Find the **tendon of the biceps brachii muscle** in the cubital fossa.
4. Cut the **bicipital aponeurosis** near the biceps brachii tendon and reflect the aponeurosis medially. Do not cut the brachial artery, which lies deep to the bicipital aponeurosis.
5. Follow the **median nerve** and the **brachial artery** from the arm into the cubital fossa. Remove any fat that may be obstructing your view of these structures.
6. Observe the relative positions of the structures in the cubital fossa (Fig. 2.12): the biceps brachii tendon is lateral, the brachial artery is intermediate, and median nerve is medial. Note that the bicipital aponeurosis passes superficial to the brachial artery and median nerve, but it lies deep to the superficial veins. The bicipital aponeurosis protects the brachial artery and median nerve from injury during venipuncture.

POSTERIOR COMPARTMENT OF THE ARM [G 505, 506; N 415; R389, 390; C 36]

1. Place the cadaver in the prone position.
2. To gain better access to the posterior compartment, rotate the arm medially.
3. Use scissors to open the posterior compartment of the arm by making a longitudinal incision through the brachial fascia from the level of the olecranon of the ulna to the teres minor muscle.
4. Use your fingers to clean and define the borders of the **triceps brachii muscle**. The triceps brachii muscle has three proximal attachments:
   - **Long head of the triceps brachii muscle** attaches to the infraglenoid tubercle of the scapula.
   - **Lateral head of the triceps brachii muscle** attaches to the posterior surface of the humerus superior to the radial groove.
   - **Medial head of the triceps brachii muscle** attaches to the posterior surface of the humerus inferior to the radial groove.
5. Observe the distal attachment of the triceps brachii tendon on the olecranon of the ulna. The triceps brachii muscle extends the forearm.
6. Use your fingers to separate the **long head of the triceps brachii** from the **lateral head.** Observe that the teres major muscle crosses the anterior surface of the long head.
7. Inferior to the teres major muscle is an opening between the long head of the triceps brachii muscle and lateral head of the triceps brachii muscle (Fig. 2.14). Use a probe to widen this opening and identify the **radial nerve** and the **deep artery of the arm.**
8. Push a probe distally along the course of the radial nerve. The probe should be positioned between the lateral head of the triceps brachii muscle and the humerus (Fig. 2.14).
9. Use a scalpel to transect the lateral head of the triceps brachii muscle over the probe. This cut will separate the lateral head of the triceps brachii muscle from the medial head.
10. Use a probe to clean the radial nerve and the deep artery of the arm. Observe that the radial nerve and deep artery of the arm lie directly on the posterior surface of the humerus in the **radial groove**.
11. Confirm the course of the radial nerve through the posterior compartment to the elbow. To do this, return to the cubital fossa. On the lateral aspect of the forearm, identify the **brachioradialis muscle**. Use your fingers to open the connective tissue plane between the brachioradialis muscle and the brachialis muscle. Deep in this plane of connective tissue, find the radial nerve.
12. Follow the radial nerve proximally. Note that the radial nerve passes on the flexor side of the elbow joint and that it is accompanied by the radial recurrent artery (Fig. 2.12).
13. Identify the **anconeus muscle** (Fig. 2.14). The proximal attachment of the anconeus muscle is the lateral epicondyle of the humerus. The distal attachment is the lateral surface of the olecranon and superior part of the posterior surface of the ulna. The anconeus muscle assists the triceps brachii muscle in extension of the forearm.

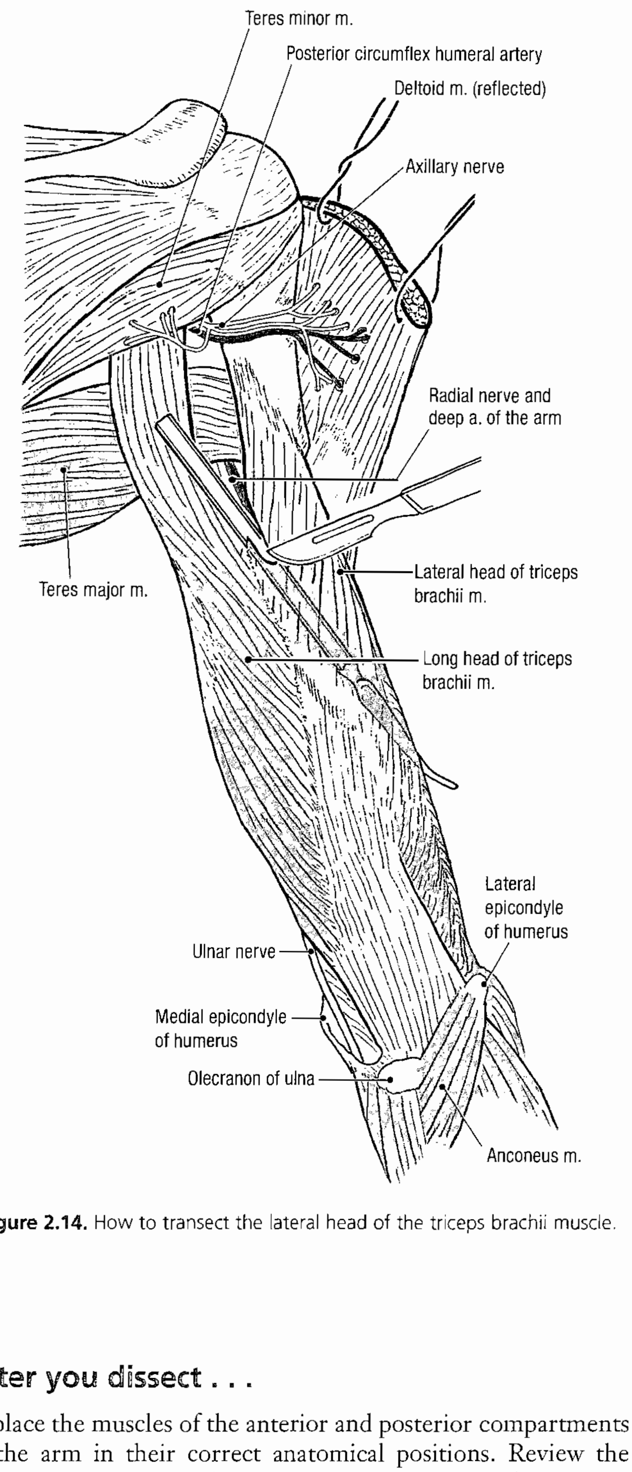


Figure 2.14. How to transect the lateral head of the triceps brachii muscle.

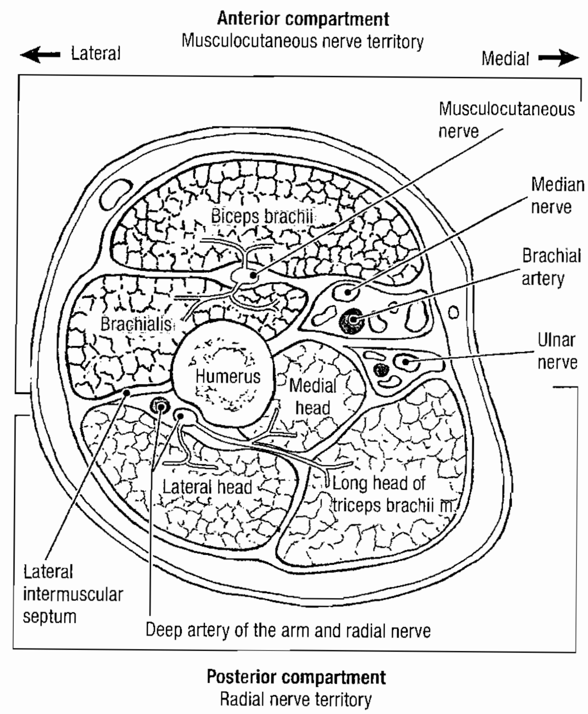


Figure 2.15. Compartments of the right arm with contents.

After you dissect . . .

Replace the muscles of the anterior and posterior compartments of the arm in their correct anatomical positions. Review the proximal attachment, distal attachment, nerve, and action of each muscle. Use the dissected specimen to review the origin, course, termination, and branches of the brachial artery. Trace each nerve that you have dissected from the brachial plexus to the elbow, reviewing relationships. Review a drawing of a cross-section of the arm and notice the position of the brachial fascia and the intermuscular septa relative to the structures that you have dissected. Review the nerve territories of the brachial region (Fig. 2.15). Recall the rules of innervation of the muscles of the arm: **all muscles in the anterior compartment of the arm are innervated by the musculocutaneous nerve. All muscles in the posterior compartment of the arm are innervated by the radial nerve.** ***The median nerve and the ulnar nerve do not innervate muscles in the arm.***

FLEXOR REGION OF THE FOREARM

Before you dissect . . .

The antebrachial fascia is a sleeve of connective tissue that invests the forearm. Intermuscular septa project inward from it and attach the antebrachial fascia to the radius and ulna (Fig. 2.16). The intermuscular septa, the interosseous membrane, the radius, and the ulna combine to divide the forearm into an **anterior (flexor) compartment** and a **posterior (extensor) compartment**. At the level of the wrist, the antebrachial fascia is thickened posteriorly to create a strong transverse band called the **extensor retinaculum.**

The muscles in the anterior compartment of the forearm can be divided into a **superficial group of flexor muscles** and a

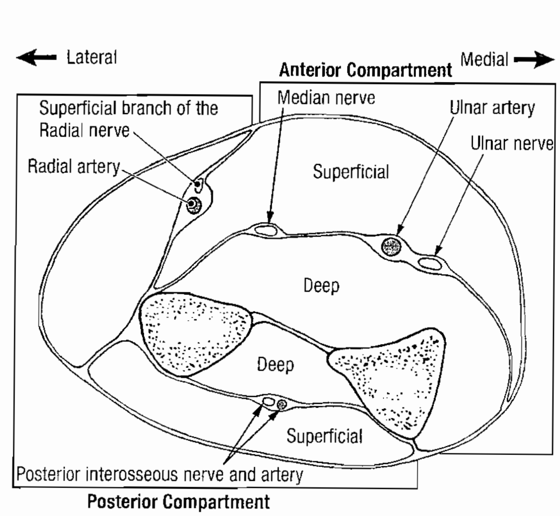


Figure 2.16. Compartments of the right forearm.

deep group of flexor muscles. Muscles of the superficial flexor group arise primarily from the medial epicondyle of the humerus and its supracondylar ridge. Muscles of the deep flexor group arise from the anterior surfaces of the radius, ulna, and interosseous membrane. Study a transverse section through the mid-level of the forearm (Fig. 2.16). Note that the ulnar artery, ulnar nerve, and median nerve are in a connective tissue plane that separates the superficial flexor group from the deep flexor group.

SKELETON OF THE FOREARM [G 524, 532, 554; N 419, 422; R 361, 362; C 76, 77]

Refer to a skeleton. On the **humerus**, identify (Fig. 2.17):

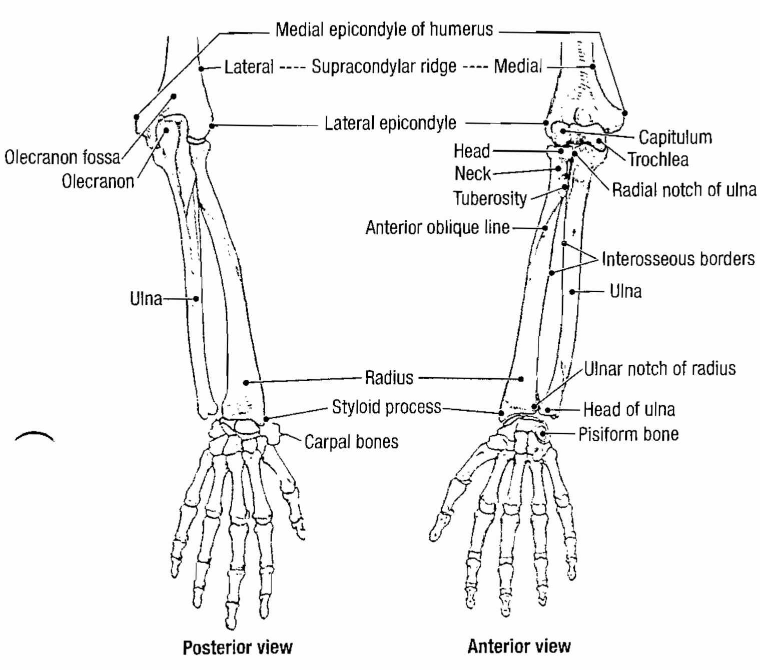
- **Medial epicondyle**
- **Medial supracondylar ridge**
- **Lateral epicondyle**
- **Lateral supracondylar ridge**
- **Capitulum**
- **Trochlea**
- **Olecranon fossa**

On the **radius** identify (Fig. 2.17):

- **Head**
- **Neck**
- **Tuberosity**
- **Anterior oblique line**
- **Ulnar notch**
- **Styloid process**
- **Interosseous border** for attachment of the **interosseous membrane**

On the **ulna** identify (Fig. 2.17):

- **Olecranon**
- **Trochlear notch**
- **Radial notch**
- **Head**
- **Interosseous border** for attachment of the interosseous membrane



On the palmar surface of the articulated hand, identify the **pisiform bone** (Fig. 2.17).

On the skeleton, examine the **elbow joint**. The elbow joint is the articulation between the trochlear notch of the ulna and the trochlea of the humerus, and the articulation between the head of the radius and the capitulum of the humerus. These two articulations account for the hinge action of the elbow joint.

Observe the **proximal radioulnar joint** between the head of the radius and the radial notch of the ulna. Observe the **distal radioulnar joint** between the head of the ulna and the ulnar notch of the radius. Pronate and supinate the hand and notice the rotational movements that occur in the proximal and distal radioulnar joints. In the position of supination (anatomical position), the radius and the ulna are parallel. In the position of pronation, the radius crosses the ulna.

The order of dissection will be as follows: the structures in the superficial fascia will be reviewed and the antebrachial fascia will be removed. At the level of the wrist, the relative positions of tendons, vessels, and nerves will be studied. The superficial group of flexor muscles will be studied and then reflected. Vessels and nerves that lie between the superficial and deep groups of flexor muscles will be studied. The deep group of flexor muscles will be dissected.

Dissection Instructions

SUPERFICIAL GROUP OF FLEXOR MUSCLES [G 534, 535; N 429; R 408; C 44]

1. Place the cadaver in the supine position and abduct the upper limb. Forcefully supinate the hand and have your dissection partner hold it in this position.
2. Use blunt dissection to remove the remnants of the superficial fascia, taking care to preserve the cephalic and basilic veins.
3. Use scissors to incise the anterior surface of the antebrachial fascia from the cubital fossa to the wrist. Use your fingers or a probe to separate the antebrachial fascia from the muscles that lie deep to it. Detach the antebrachial fascia from its attachments to the radius and ulna and place it in the tissue container.
4. Use blunt dissection to clean the **superficial group of flexor muscles**. There are five muscles in this group: **Pronator teres, flexor carpi radialis, palmaris longus, flexor carpi ulnaris**, and **flexor digitorum superficialis**. Note that part of the proximal attachment of these muscles is from a **common flexor tendon**. The common flexor tendon is attached to the medial epicondyle of the humerus.
5. Note the distal attachment and action of each muscle of the superficial group of flexors:
   - **Pronator teres muscle** attaches to the middle of the lateral surface of the radius. The pronator teres muscle pronates the hand and flexes the forearm.
   - **Flexor carpi radialis tendon** attaches to the base of the second metacarpal bone. The flexor carpi radialis muscle flexes and abducts the hand.
   - **Palmaris longus tendon** attaches to the palmar aponeurosis. The palmaris longus muscle flexes the hand.

- **Flexor carpi ulnaris tendon** attaches to the pisiform bone, hamate bone, and the base of the fifth metacarpal bone. The flexor carpi ulnaris muscle flexes and adducts the hand.
- **Flexor digitorum superficialis tendon** attaches to the middle phalanx of digits 2 to 5. The flexor digitorum superficialis muscle flexes the middle phalanx of digits 2 to 5.

6. Use your fingers to separate the tendons of the superficial group of flexor muscles. Note that the muscle bellies cannot be easily separated from each other. From lateral to medial, identify the superficial structures at the wrist (Fig. 2.18): **[G 539; N 429; R 408; C 44]**
   - Tendon of the **abductor pollicis longus muscle**
   - **Radial artery**
   - Tendon of the **flexor carpi radialis muscle**
   - **Median nerve**
   - Tendon of the **palmaris longus muscle** (absent in 13% of limbs)
   - Four tendons of the **flexor digitorum superficialis muscle**
   - **Ulnar artery** and **ulnar nerve**
   - Tendon of the **flexor carpi ulnaris muscle**
7. Palpate the tendons listed above in your own wrist. Feel the pulse of the radial artery between the tendons of the abductor pollicis longus and flexor carpi radialis muscles. The median nerve is superficial at the wrist and can be easily injured. Palpate the distal attachment of the flexor carpi ulnaris tendon on the pisiform bone. Palpate the ulnar nerve and artery, which lie immediately lateral to the pisiform bone.

VESSELS AND NERVES [G 536; N 430; R 408; C 48]

1. On the lateral side of the proximal forearm, identify the **brachioradialis muscle.** At the point where the pronator teres muscle passes deep to the brachioradialis muscle, use your fingers to open the connective tissue plane that is medial to the brachioradialis muscle. In this intermuscular plane, identify the **superficial branch of the radial nerve**, which courses distally on the deep surface of the brachioradialis muscle. Trace the superficial branch of the radial nerve distally and confirm that it becomes subcutaneous near the wrist.
2. Once again, identify the **brachial artery** in the cubital fossa. Use blunt dissection to trace the brachial artery distally until it bifurcates into the **radial artery** and the **ulnar artery.**

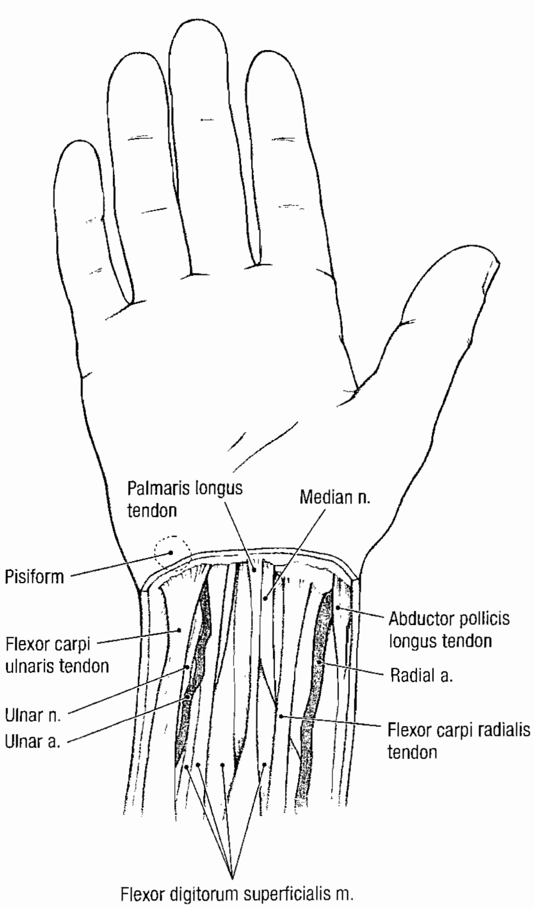


Figure 2.18. Structures of the anterior aspect of the wrist.

CLINICAL CORRELATION

High Bifurcation of the Brachial Artery

In approximately 3% of upper limbs, the brachial artery bifurcates in the arm. When it does, the ulnar artery may course superficial to the superficial group of flexor muscles. When this happens, the ulnar artery may be mistaken for a vein. When certain drugs are injected into an artery, the capillary bed is damaged, followed by gangrene. In the example of the ulnar artery, the hand could be severely injured.

3. Use a probe to clean the radial artery and follow it distally to the level of the wrist. The radial vein and its tributaries may be removed to clear the dissection field. The radial artery gives rise to several unnamed muscular branches in the forearm.
4. Find the **radial recurrent artery**, which arises from the radial artery near its origin from the brachial artery. The radial recurrent artery courses proximally in the connective tissue plane between the brachioradialis muscle and the brachialis muscle. The radial recurrent artery anastomoses with the radial collateral branch of the deep artery of the arm. The radial recurrent artery is part of the anastomotic network around the elbow (Fig. 2.13).
5. Identify the **median nerve** in the cubital fossa. It is medial to the brachial artery. The median nerve innervates most of the muscles of the flexor compartment of the forearm.

6. Follow the median nerve distally. The median nerve courses deep to the superficial group of flexor muscles. To expose the median nerve, use scissors to cut the tendon of the palmaris longus muscle approximately 3 cm proximal to the wrist and reflect the muscle belly proximally. Cut the tendon of the flexor carpi radialis muscle approximately 5 cm proximal to the wrist and reflect it proximally.
7. Insert a probe through the pronator teres muscle along the anterior surface of the median nerve. Use scissors to cut the portion of the pronator teres muscle that lies anterior to the median nerve. Use a probe to release the median nerve and follow it distally.
8. Observe that the median nerve passes deep to the flexor digitorum superficialis muscle. Use scissors to detach the flexor digitorum superficialis muscle from its proximal attachment to the radius. Retract the muscle medially, leaving its ulnar and humeral attachments undisturbed.
9. Use a probe to free the median nerve from the loose connective tissue that lies between the superficial and deep groups of forearm flexor muscles (Fig. 2.16). Observe that the median nerve innervates the palmaris longus, flexor carpi radialis, flexor digitorum superficialis, and pronator teres muscles.
10. Find the **ulnar artery** in the cubital fossa. The ulnar artery passes posterior to the deep part of the pronator teres muscle. To follow the ulnar artery distally, release it from the pronator teres muscle. Insert a probe through the pronator teres muscle along the anterior surface of the ulnar artery (posterior to the deep part of the pronator teres muscle). Use scissors to cut the deep part of the pronator teres muscle. The pronator teres muscle is now completely transected and it may be reflected to broaden the dissection field.
11. Use a probe to clean the ulnar artery and follow it from the cubital fossa to the wrist. The ulnar vein and its tributaries may be removed to clear the dissection field. Observe that the median nerve crosses anterior to the ulnar artery in the cubital fossa. Note that the ulnar artery passes between the flexor digitorum superficialis and the flexor digitorum profundus muscles to reach the ulnar (medial) side of the forearm.
12. Find the **common interosseous artery**. It arises approximately 3 cm distal to the origin of the ulnar artery from the brachial artery. The common interosseous artery is usually quite short. It passes posterolaterally toward the interosseous membrane before dividing into the **anterior interosseous artery** and the **posterior interosseous artery**.
13. Identify the **anterior interosseous artery** on the anterior surface of the interosseous membrane. The anterior interosseous artery supplies the deep group of flexor muscles.
14. The **posterior interosseous artery** passes over the proximal end of the interosseous membrane to reach the posterior compartment of the forearm. The posterior interosseous artery supplies the extensor group of forearm muscles. Identify it, but do not attempt to follow it into the posterior compartment at this time.
15. Two other named vessels arise from the ulnar artery in the proximal forearm: **anterior ulnar recurrent artery** and **posterior ulnar recurrent artery**. They anastomose with the superior and inferior ulnar collateral branches of the brachial artery, respectively (Fig. 2.13). Do not attempt to find these vessels. Note that unnamed muscular branches arise from the ulnar artery in the forearm.
16. Observe that the ulnar artery joins the **ulnar nerve** approximately one-third of the way down the forearm.
17. Follow the ulnar nerve proximally and observe that it passes between the two heads of the flexor carpi ulnaris muscle. The ulnar nerve innervates the flexor carpi ulnaris muscle and the medial one-half of the flexor digitorum profundus muscle.

DEEP GROUP OF FLEXOR MUSCLES [G 537; N 431; R 409; C 50]

1. Three muscles comprise the **deep group of flexor muscles**: **flexor digitorum profundus**, **flexor pollicis longus**, and **pronator quadratus**.
2. The proximal attachment of the **flexor digitorum profundus muscle** is the anterior surface of the ulna and interosseous membrane. Distally, the flexor digitorum profundus tendons attach to the distal phalanx of digits 2 to 5. The flexor digitorum profundus muscle flexes the distal phalanx of digits 2 to 5. The lateral one-half of the flexor digitorum profundus muscle is innervated by the median nerve. The medial one-half of the flexor digitorum profundus muscle is innervated by the ulnar nerve.
3. The proximal attachment of the **flexor pollicis longus muscle** is the anterior surface of the radius and interosseous membrane. The distal attachment of the flexor pollicis longus tendon is the distal phalanx of digit 1 (thumb). The flexor pollicis longus muscle flexes digit 1.
4. The **pronator quadratus muscle** lies posterior to the tendons of the superficial and deep flexor muscles. Its fibers run transversely from the ulna to the radius in the distal one-fourth of the forearm. Retract the tendons of the superficial and deep groups of flexor muscles and find the pronator quadratus muscle. The pronator quadratus muscle pronates the hand.
5. Observe that the **anterior interosseous artery and nerve** pass posterior to the pronator quadratus muscle.

After you dissect . . .

Replace the flexor muscles in their correct anatomical positions. Use the dissected specimen to review the proximal attachment, distal attachment, and action of each muscle dissected. Organize these muscles into a superficial group and a deep group and recall that the nerves and vessels that course through the forearm are found between the two groups. Follow the brachial artery from its origin in the proximal arm to its bifurcation in the cubital fossa. Review all of the branches of the radial and ulnar arteries. Trace the course of these two arteries from the elbow to the wrist. Review the course of the median nerve from the

brachial plexus to the wrist. Review the course of the ulnar nerve from the brachial plexus to the wrist. Recall the rule for innervation of the muscles in the anterior compartment of the forearm: **all muscles of the anterior compartment of the forearm are innervated by the median nerve** ***except the flexor carpi ulnaris muscle and the medial one-half of the flexor digitorum profundus muscle, which are innervated by the ulnar nerve.***

PALM OF THE HAND

Before you dissect . . .

The **intrinsic hand muscles** have their proximal and distal attachments within the hand. There are two superficial groups of intrinsic hand muscles: the **thenar group of muscles** forms the **thenar eminence**, and the **hypothenar group of muscles** forms the **hypothenar eminence**. Deep in the hand is a third group of intrinsic hand muscles: the interosseous muscles and the adductor pollicis muscle.

In the middle of the palm, the palmar fascia is thickened to form the palmar aponeurosis. The palmar fascia over the thenar and hypothenar eminences is much thinner. Deep to the palmar aponeurosis are the tendons of the superficial and deep digital flexor muscles. These tendons reach the palm through the carpal tunnel and are responsible for flexing the digits. In the deepest part of the palm are small muscles that abduct and adduct the digits.

The palm is supplied with blood by two arterial arches. The superficial arch is mainly derived from the ulnar artery and the deep arch from the radial artery. The nerve supply of the palmar aspect of the hand is derived from the median and ulnar nerves.

The order of dissection will be as follows: the palmar aponeurosis will be studied and removed. The superficial palmar arch will be dissected, followed by the tendons of the muscles of the anterior compartment of the forearm. The flexor retinaculum will be cut and the flexor tendons will be released from the palm. The muscles of the thenar group will be dissected, followed by the muscles of the hypothenar group. The deep palmar arch will be dissected along with the deep branch of the ulnar nerve. The interosseous muscles will be studied.

SKELETON OF THE HAND [G 532, 554; N 439; R 364, 365; C 78, 79]

Refer to an articulated skeleton of the hand and identify (Fig. 2.19):

- **Eight carpal bones** (Gr. *karpos*, wrist)
- **Five metacarpal bones**
- **14 phalanges**

Be able to identify the eight carpal bones in an articulated skeleton. Digit 1 (thumb) has two phalanges: proximal and distal. Digits 2 to 5 (fingers) have three phalanges: proximal, middle, and distal.

Identify the **pisiform bone** and the **hook of the hamate** on the medial side of the wrist. On the lateral side of the wrist, identify the **tubercle of the scaphoid** and the **tubercle of the trapezium**. The **flexor retinaculum** bridges these four bones (Fig. 2.20). The space between the carpal bones and the flexor retinaculum is the **carpal tunnel**, which allows passage of the flexor tendons and the median nerve into the hand.

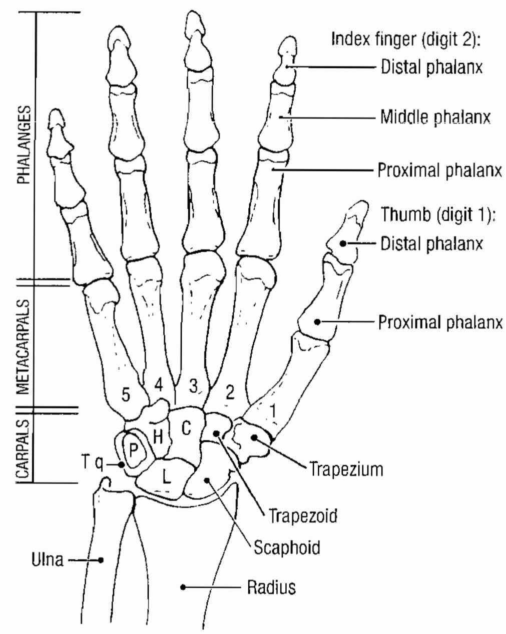


Figure 2.19. Skeleton of the hand. The eight carpal bones include a proximal row of four bones (scaphoid; lunate, *L*; triquetrum, *Tq*; pisiform, *P*) and a distal row of four bones (trapezium; trapezoid; capitate, C; hamate, *H*).

Dissection Instructions

SUPERFICIAL PALM [G 541; N 442, 443; R 412; C 62, 68]

1. Use scraping motions with a dull scalpel blade to clean the fat from the **palmar aponeurosis.** Observe that the palmar aponeurosis has four bands of **longitudinal fibers**, one band to each of digits 2 to 5. These longitudinal fibers end by attaching to the fibrous digital sheath near the base of the proximal phalanx of each digit.
2. Identify the fascia of the **thenar muscles** lateral to the palmar aponeurosis.
3. Identify the fascia of the hypothenar muscles medial to the palmar aponeurosis. The **palmaris brevis muscle** is found superficial to the hypothenar muscles. It is a thin, fragile muscle. The proximal attachment of the

CARPAL TUNNEL WITH CONTENTS

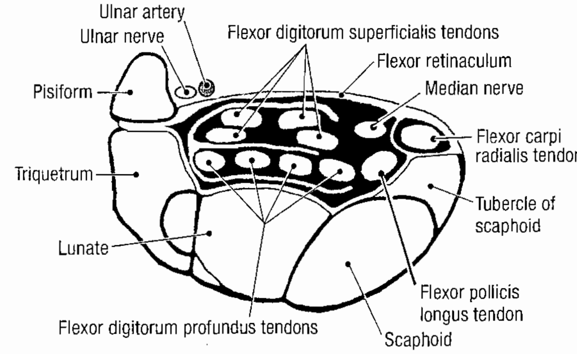


Figure 2.20. Transverse section through the left carpal tunnel.

palmaris brevis muscle is the medial aspect of the palmar aponeurosis. Its distal attachment is the skin over the hypothenar eminence.

4. Detach the palmaris brevis muscle from the palmar aponeurosis and reflect it medially.
5. Find the tendon of the **palmaris longus muscle** where you transected it in the forearm. Follow the palmaris longus tendon distally into the palm, where it is attached to the palmar aponeurosis. Although the palmaris longus muscle may be absent, the palmar aponeurosis is always present.
6. Remove the palmar aponeurosis. Use a scalpel and skinning motions to detach the palmar aponeurosis from the underlying deep structures. Begin at its proximal end and proceed distally. Use the palmaris longus tendon to apply traction to the palmar aponeurosis during its removal. Do not cut too deeply, because the superficial palmar arch is in contact with the deep surface of the palmar aponeurosis.
7. Near the proximal end of digits 2 to 5, remove the band of longitudinal fibers of the palmar aponeurosis. Use blunt dissection to clean the **fibrous digital sheath** on the flexor surface of digit 3 (Fig. 2.21).
8. Find the **ulnar artery** in the forearm. Use a probe to dissect the ulnar artery and follow it into the palm. The ulnar artery passes lateral to the pisiform bone with the ulnar nerve, and then divides into a **superficial branch** and a **deep palmar branch.** The superficial branch of the ulnar artery crosses the palm to form the **superficial palmar arch**. The superficial palmar arch is completed by a smaller contribution from the **superficial palmar branch of the radial artery** (Fig. 2.22). **[G 546; N 443; R 414; C 68]**
9. Use a probe to clean the superficial palmar arch and the three **common palmar digital arteries** arising from it. Trace one common palmar digital artery distally and note that it divides into two **proper palmar digital arteries** that supply the adjacent sides of two digits.
10. Find the **ulnar nerve** lateral to the pisiform bone. Use a probe to dissect the **superficial branch of the ulnar nerve**, which supplies cutaneous innervation to digit 5 and the medial side of digit 4. The **deep branch of the ulnar nerve** disappears into the hypothenar muscles. Identify the initial portion of the deep branch of the ulnar nerve but do not follow it at this time.

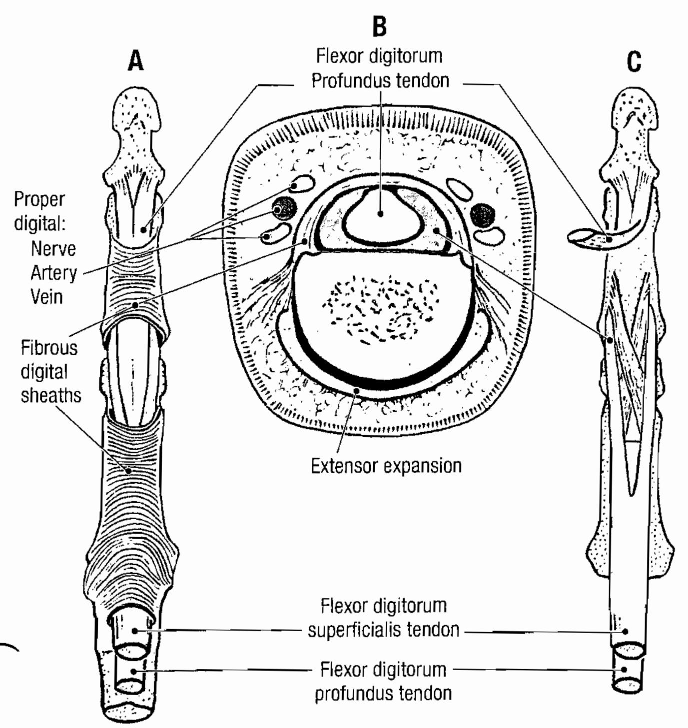


Figure 2.21. Flexor tendons in the finger. **A.** Fibrous digital sheath showing the two osseofibrous tunnels. **B.** Transverse section of a finger showing the fibrous digital sheath surrounding the flexor tendons. **C.** Distal attachment of the flexor tendons.

CARPAL TUNNEL [G 547; N 444; R 415; C 65]

1. Identify the **flexor retinaculum** between the thenar and hypothenar eminences. Use an illustration to review the flexor retinaculum and its role in the formation of the **carpal tunnel** (Fig. 2.21).
2. Insert a probe from proximal to distal, deep to the flexor retinaculum (Fig. 2.23). Use a scalpel to cut through the flexor retinaculum to the probe. Open the carpal tunnel.
3. Examine the **contents of the carpal tunnel**: **median nerve, four tendons of the flexor digitorum superficialis muscle, four tendons of the flexor digitorum profundus muscle**, and the **tendon of the flexor pollicis longus muscle.**
4. Find the median nerve at the level of the wrist and follow it through the carpal tunnel. Identify the **recurrent branch of the median nerve**, which innervates the three thenar muscles (Fig. 2.23). The median nerve also innervates **lumbrical muscles 1 and 2.**
5. Follow the **common palmar digital branches** of the median nerve to the lateral 3 1/2: digits (Fig. 2.22). Note that the common palmar digital nerves typically divide to give rise to two **proper palmar digital nerves**, which accompany the proper palmar digital arteries. Use an illustration to study the cutaneous distribution of the median nerve in the hand. **[G 559; N 455; R 409; C 24]**
6. Identify the flexor tendons that pass through the carpal tunnel. Observe that these tendons pass through the palm of the hand posterior to the superficial palmar arch and digital nerves. The flexor tendons enter the **fibrous digital sheaths** on the anterior surfaces of the digits (Fig. 2.21).
7. Use an illustration to study the extent of the synovial tendon sheaths deep to the flexor retinaculum and extending into the palm. There are two sets of synovial sheaths: one **common flexor sheath (ulnar bursa)** and three **digital synovial sheaths.** The tendon of the flexor pollicis longus muscle has it own synovial sheath (**radial bursa**). **[G 548; N 445, 446; R 378, 379; C 63]**

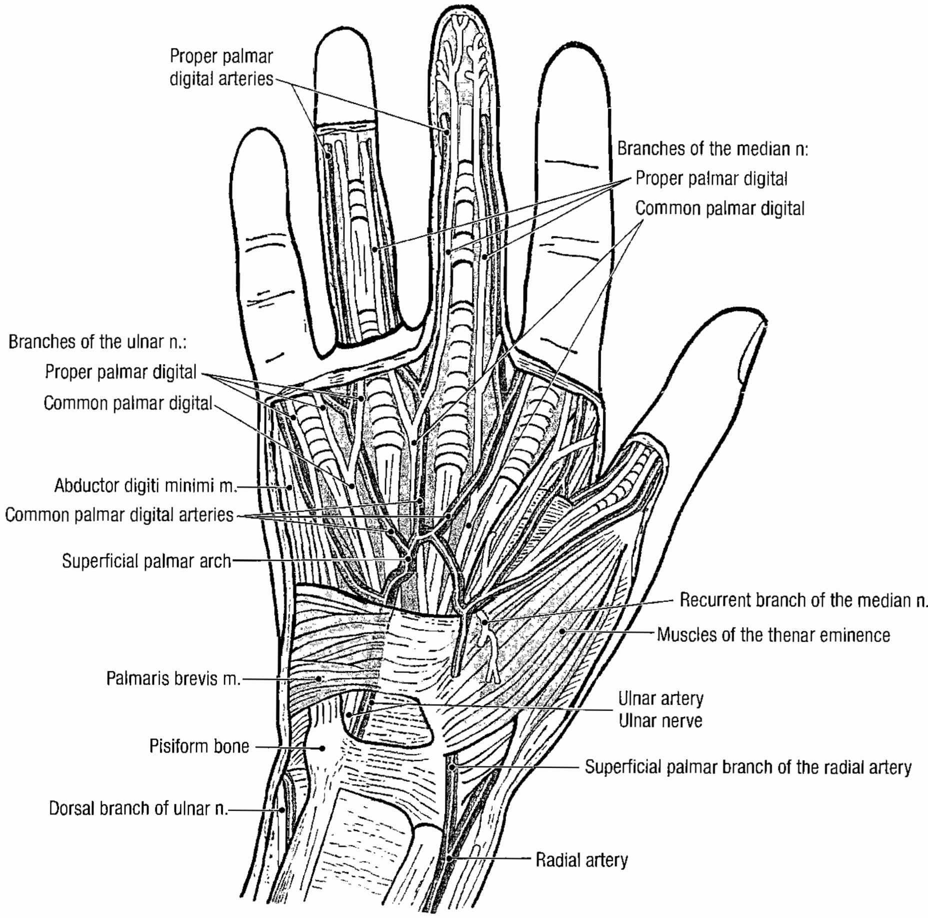


Figure 2.22. Superficial dissection of the palm.

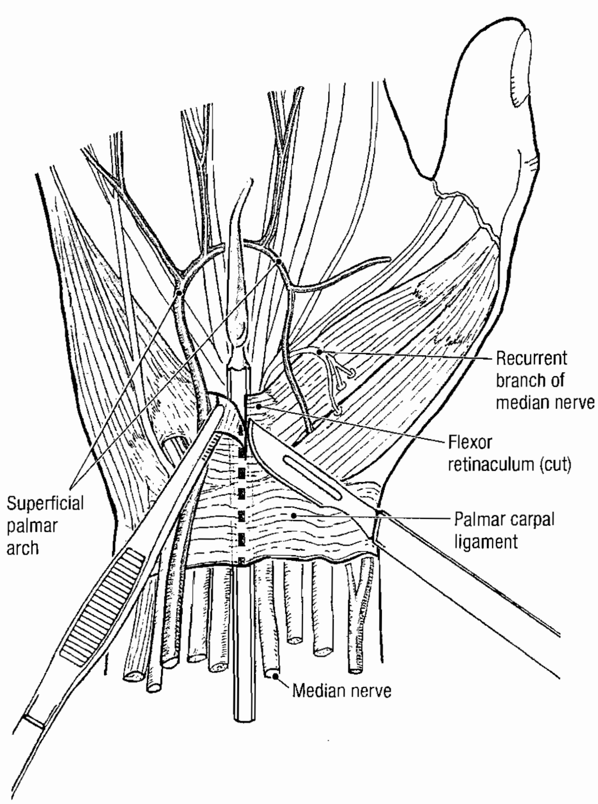


Figure 2.23. How to open the carpal tunnel.

CLINICAL CORRELATION

Carpal Tunnel Syndrome

A swelling of the common flexor sheath may encroach on the available space in the carpal tunnel. As a result, the median nerve may be compressed resulting in pain and paresthesia of the thumb, index finger, and middle finger, and weakness of the thenar muscles.

8. In the distal forearm, use your fingers to separate the tendons of the **flexor digitorum superficialis** muscle from the tendons of the **flexor digitorum profundus muscle**. Approximately 5 cm proximal to the wrist, use scissors to transect the tendons of the flexor digitorum superficialis muscle. Reflect the tendons distally, pulling them through the carpal tunnel. During this procedure, the common flexor sheath will be destroyed. To reflect the tendons even further, cut the superficial palmar arch in the midline of the palm, retract the common digital branches of the median and ulnar nerves, and make a longitudinal slit in the fibrous digital sheaths of digits 2 to 5.

9. In the palm, observe the tendons of the **flexor digitorum profundus muscle**. Identify four **lumbrical muscles** that are attached to the four tendons of the flexor digitorum profundus muscle. The distal attachment of the lumbrical muscles is the radial side of the **extensor expansions** of digits 2 to 5 (Fig. 2.24). The lumbrical muscles flex the metacarpophalangeal joints and extend the interphalangeal joints.
10. In digit 3, study the **relationship of the tendons of the flexor digitorum superficialis** and **flexor digitorum profundus muscles** (Fig. 2.24). Note that the tendon of the flexor digitorum profundus splits the tendon of the flexor digitorum superficialis. Verify that the flexor digitorum superficialis tendon attaches to the middle phalanx, whereas the flexor digitorum profundus tendon attaches to the distal phalanx. This pattern is true of digits 2 to 5.
11. Identify the **flexor pollicis longus muscle** in the forearm. Follow its tendon distally through the carpal tunnel into the palm. Pull on the tendon to confirm that the flexor pollicis longus muscle attaches to the distal phalanx of the thumb.

THENAR MUSCLES [G 548, 550; N 448; R 412; C 64]

1. Use blunt dissection to clean the palmar surface of the thenar muscles.
2. The thenar group contains three muscles: **abductor pollicis brevis, flexor pollicis brevis**, and **opponens pollicis** (L. *pollex*, thumb; genitive, *pollicis*). The proximal attachments of the thenar muscles are the scaphoid, trapezium, and flexor retinaculum.
   - **Abductor pollicis brevis muscle** attaches to the lateral side of the proximal phalanx of the thumb and it abducts the thumb.
   - **Flexor pollicis brevis muscle** attaches to the lateral side of the proximal phalanx of the thumb and it flexes the thumb.
   - **Opponens pollicis muscle** attaches to the lateral side of the shaft of the first metacarpal bone and it opposes the thumb.
3. Observe the **recurrent branch of the median nerve**. The recurrent branch of the median nerve crosses the superficial surface of the flexor pollicis brevis muscle, and then disappears deep to the abductor pollicis brevis muscle.
4. Use a probe to separate the abductor pollicis brevis muscle from the flexor pollicis brevis muscle. Use the recurrent branch of the median nerve to help locate the correct plane of separation.
5. Use a probe to elevate the abductor pollicis brevis muscle and transect it with scissors.
6. Observe the **opponens pollicis muscle** deep to the abductor pollicis brevis muscle. Note that the opponens pollicis muscle attaches to the lateral side of the entire length of the shaft of the first metacarpal bone.

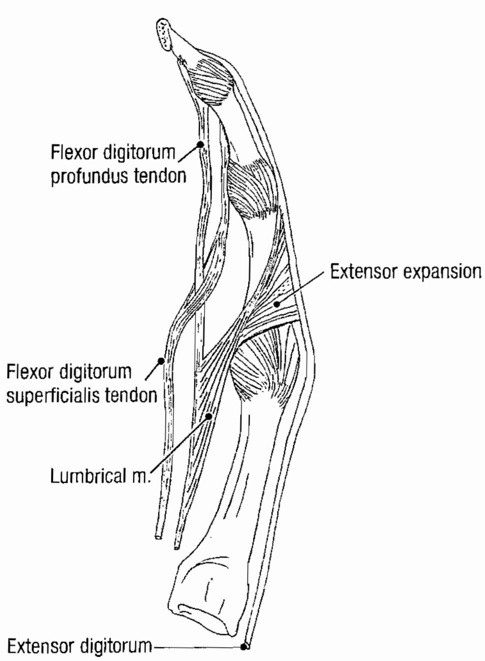


Figure 2.24. Extensor expansion.

CLINICAL CORRELATION

Recurrent Branch of the Median Nerve

The recurrent branch of the median nerve is superficial and it can easily be severed by "minor" cuts over the thenar eminence. If the recurrent branch of the median nerve is injured, the thenar muscles are paralyzed and the thumb cannot be opposed.

HYPOTHENAR MUSCLES [G 548, 550; N 448; R 412; C 64]

1. Use blunt dissection to clean the palmar surface of the hypothenar muscles. The hypothenar group contains three muscles: **abductor digiti minimi, flexor digiti minimi brevis**, and **opponens digiti minimi**. The proximal attachments of the hypothenar muscles are the pisiform, hamate, and flexor retinaculum.
   - **Abductor digiti minimi muscle** attaches to the medial side of the base of the proximal phalanx of digit 5 and it abducts digit 5.
   - **Flexor digiti minimi brevis muscle** attaches to the medial side of the base of the proximal phalanx of digit 5and it flexes digit 5.
   - **Opponens digiti minimi muscle** attaches to the medial border of the fifth metacarpal bone and it opposes digit 5.
2. Use a probe to define the borders of the abductor digiti minimi muscle and the flexor digiti minimi brevis muscle. Use the tendons at the distal attachment to aid in this separation.
3. Use a probe to elevate the abductor digiti minimi brevis muscle and detach it from its proximal attachment on the flexor retinaculum. Preserve the deep branches of the ulnar artery and ulnar nerve.

4. Observe the **opponens digiti minimi muscle**. Note that the opponens digiti minimi muscle attaches to the entire length of the shaft of the fifth metacarpal bone.

DEEP PALM [G 550, 551; N 448, 449; R 412; C 69]

1. Transect the flexor digitorum profundus muscle in the distal one-third of the forearm. Reflect its tendons and the associated lumbrical muscles distally as far as possible. The deep palm is now exposed.
2. Find the ulnar nerve and the ulnar artery on the lateral side of the pisiform bone.
3. The **deep branch of the ulnar nerve** and the **deep palmar branch of the ulnar artery** pass between the proximal attachments of the flexor digiti minimi brevis and abductor digiti minimi muscles.
4. Push a probe parallel to the deep branch of the ulnar nerve where it pierces the opponens digiti minimi muscle. Use a scalpel to cut down to the probe. Use blunt dissection to follow the deep branch of the ulnar nerve into the palm.
5. Observe that the deep branch of the ulnar nerve lies on the anterior surface of the interosseous muscles (Fig. 2.25A).
6. Observe the **deep palmar arch.** The deep palmar arch courses with the deep branch of the ulnar nerve. The deep palmar arch arises from the **radial artery**. The deep palmar arch is completed by the deep branch of the ulnar artery. Use an illustration to study the branches of the deep palmar arch.
7. Identify the **adductor pollicis muscle** (Fig. 2.25A). Use blunt dissection to define its borders. The adductor pollicis muscle has two heads: **oblique** and **transverse.** The proximal attachments of the oblique head are the bases of metacarpal bones 2 and 3 and the adjacent carpal bones. The proximal attachment of the transverse head is the anterior surface of the shaft of metacarpal bone 3. Both heads attach to the medial side of the base of the proximal phalanx of the thumb. The adductor pollicis muscle draws the thumb toward digit 3 (adduction).
8. Use an illustration to study the three **palmar interosseous muscles** (Fig. 2.25A). The palmar interosseous muscles are unipennate muscles that attach to the metacarpal bones of digits 2, 4, and 5. Distally, the palmar interosseous muscles attach to the bases of the proximal phalanges and the extensor expansions. Do not dissect these muscles. **[G 545; N 448; R 416; C 66]**
9. Use an illustration to study the four **dorsal interosseous muscles** (Fig. 2.25B). The dorsal interosseous muscles are bipennate muscles that attach to metacarpal bones 1 to 5. Distally, the dorsal interosseous muscles attach to the bases of the proximal phalanges and the extensor expansions of digits 2 to 4. Look at the dorsum of the dissected hand and note that the dorsal interosseous muscles occupy the intervals between the metacarpal bones. Do not dissect these muscles.
10. Study the actions of the interosseous muscles (Fig. 2.25). The three **P**almar interosseous muscles are **AD**ductors (**PAD**). They adduct digits 2, 4, and 5 toward an imaginary axial line drawn through the long axis of digit 3. The four **D**orsal interosseous muscles are **AB**ductors (**DAB**). They move digits 2 to 4 away from the imaginary axial line. The two dorsal interosseous muscles that attach to digit 3 move it to either side of the imaginary axial line. The interosseous muscles are innervated by the deep branch of the ulnar nerve.

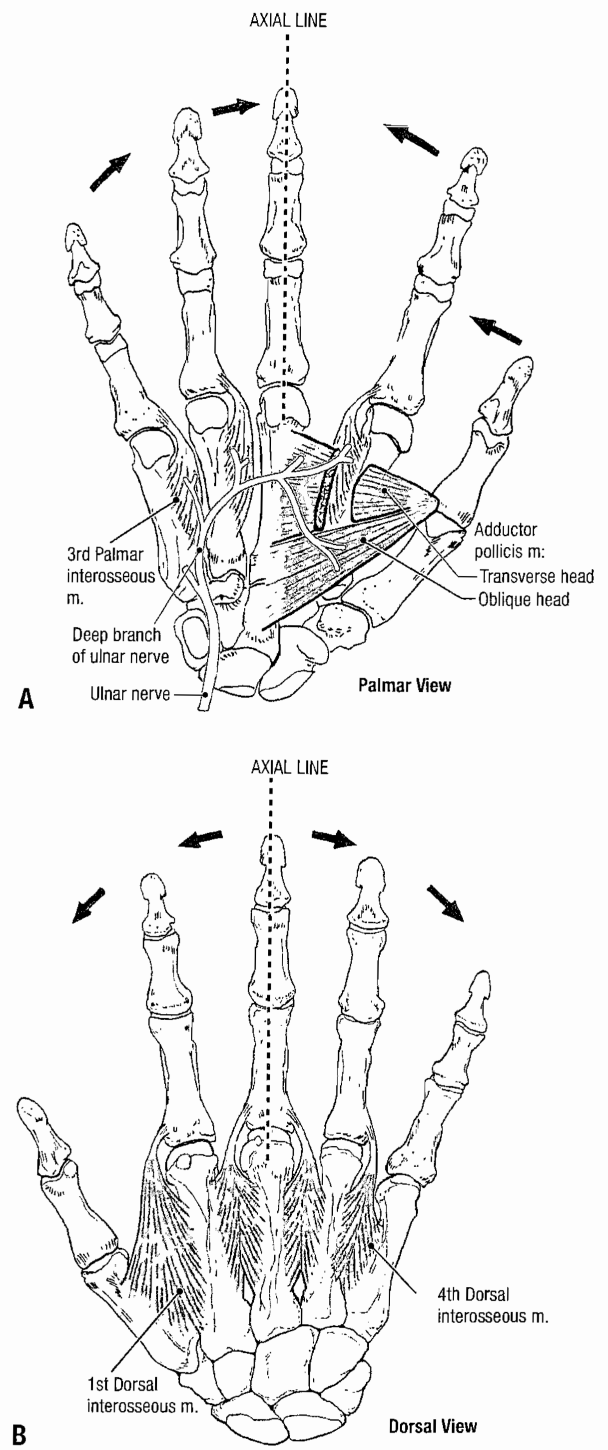


Figure 2.25. A. The three unipennate **P**almar interosseous muscles **AD**duct (**PAD**) the fingers (arrows) in relation to the axial line. **B.** The four bipennate **D**orsal interosseous muscles **AB**duct (**DAB**) the fingers (arrows).

After you dissect . . .

Place the muscles, tendons, and nerves that you have dissected back into their correct anatomical positions. Review the movements of the fingers and thumb. Define flexion, extension, abduction, and adduction. Review the muscles that are responsible for each action. Use the dissected specimen to follow the median nerve from the forearm into the hand. Follow the ulnar artery from the elbow to the hand. In the hand, trace the superficial branch and deep palmar branch of the ulnar artery. Follow the ulnar nerve from the medial epicondyle of the humerus to the hand. In the hand, trace the superficial and deep branches of the ulnar nerve. Review an illustration that demonstrates the cutaneous distribution of the ulnar and median nerves in the hand. Recall the rule for innervation of the muscles in the hand: **all intrinsic muscles of the hand are innervated by the ulnar nerve** ***except the muscles of the thenar group and the first two lumbrical muscles, which are innervated by the median nerve.*** **[G 462; N 455; R 388]**

EXTENSOR REGION OF THE FOREARM AND DORSUM OF THE HAND

Before you dissect . . .

The posterior compartment of the forearm contains the extensor muscles of the forearm. They can be divided into a superficial group and a deep group (Fig. 2.16). The muscles of the superficial group extend the wrist and the proximal phalanges. The muscles of the deep group of extensors cause supination of the hand, extension of digit 2, and abduction and extension of the thumb. The deep branch of the radial nerve innervates the extensor muscles of the forearm. Nerves and vessels of the posterior compartment run in the connective tissue plane that divides the superficial group of extensor muscles from the deep group of extensor muscles.

In the dorsum of the hand, the bones are superficial. There are no intrinsic muscles in the dorsum of the hand, so no motor innervation is required. The radial, ulnar, and median nerves share the cutaneous innervation of the dorsum of the hand.

The order of dissection will be as follows: the antebrachial fascia will be removed from the elbow to the wrist. The muscles of the superficial extensor group will be identified and followed to their distal attachments in the hand. The tendons of the superficial extensor muscles will be released from the extensor retinaculum and retracted to permit the muscles of the deep extensor group to be studied. The contents of the anatomical snuffbox will be identified.

Dissection Instructions

SUPERFICIAL GROUP OF EXTENSOR MUSCLES [G 556; N 427; R 403; C 52]

1. Place the cadaver in the supine position.
2. Use blunt dissection to remove the remnants of the superficial fascia from the posterior forearm and dorsum of the hand, taking care to preserve the dorsal venous arch.
3. Identify the **extensor retinaculum**, which is located on the posterior surface of the distal forearm.
4. Use scissors to incise the posterior surface of the antebrachial fascia from the olecranon to the extensor retinaculum. Preserve the extensor retinaculum. Use your fingers or a probe to separate the antebrachial fascia from the muscles that lie deep to it. Detach the antebrachial fascia from its attachments to the radius and ulna and place it in the tissue container.
5. Six muscles comprise the **superficial extensor group**: **brachioradialis**, **extensor carpi radialis longus**, **extensor carpi radialis brevis**, **extensor digitorum**, **extensor digiti minimi**, and **extensor carpi ulnaris**. Note that four of the muscles in the superficial extensor group (extensor carpi radialis brevis, extensor digitorum, extensor digiti minimi, and extensor carpi ulnaris) attach to the lateral epicondyle of the humerus by way of a **common extensor tendon**.
6. Use tendon patterns at the wrist and distal attachments to positively identify the muscles of the superficial extensor group:
   - **Brachioradialis tendon** attaches to the lateral surface of the distal radius.
   - **Extensor carpi radialis longus tendon** attaches to the base of metacarpal bone 2.
   - **Extensor carpi radialis brevis tendon** attaches to the base of metacarpal bone 3.
   - **Extensor digitorum tendons** attach to the extensor expansions of digits 2 to 5.
   - **Extensor digiti minimi tendon** attaches to the extensor expansion of digit 5.
   - **Extensor carpi ulnaris tendon** attaches to the base of metacarpal bone 5.
7. Note that the tendons of the extensor digitorum longus muscle are tied together by **intertendinous connections** on the posterior surface of the hand. **[G 562; N 453; R 404; C 60]**
8. Observe the **extensor expansion** of digit 3 (Fig. 2.24). The extensor expansion is wrapped around the dorsum and the sides of the proximal phalanx and the distal end of the metacarpal bone. The hood-like expansion retains the extensor tendon in the midline of the digit. The tendons of the lumbrical and interosseous muscles attach to the extensor expansion. **[G 563; N 447; R 404; C 65]**
9. Cut through the **extensor retinaculum** to release the tendons of the extensor digitorum muscle. Retract the tendons medially. Note that the other extensor tendons are also contained within individual osseofibrous tunnels. Synovial sheaths line these tunnels.

DEEP GROUP OF EXTENSOR MUSCLES [G 557; N 428; R 403; C 54]

1. Five muscles comprise the **deep extensor group**: **abductor pollicis longus**, **extensor pollicis brevis**, **extensor pollicis longus**, **extensor indicis**, and **supinator**.
2. The proximal attachments of four muscles of the deep extensor group (abductor pollicis longus, extensor

pollicis brevis, extensor pollicis longus, and extensor indicis) are the posterior surfaces of the radius, ulna, and interosseous membrane. These four muscles emerge from the interval between the extensor digitorum muscle and the extensor carpi radialis brevis muscle.

3. Observe the tendon of each of the following muscles and follow it to its distal attachment:
   - **Abductor pollicis longus tendon** attaches to the base of metacarpal bone 1.
   - **Extensor pollicis brevis tendon** attaches to the base of the proximal phalanx of digit 1.
   - **Extensor pollicis longus tendon** attaches to the base of the distal phalanx of digit 1.
   - **Extensor indicis tendon** attaches to the extensor expansion of digit 2.
4. Identify the **anatomical snuffbox** (Fig. 2.26). The anatomical snuffbox is the depression on the posterior surface of the wrist that is bounded anteriorly by the **abductor pollicis longus tendon** and the **extensor pollicis brevis tendon**. The posterior boundary of the anatomical snuffbox is the **extensor pollicis longus tendon**. [G 564, 565; N 452; R 404; C 59]
5. Within the anatomical snuffbox, find the **radial artery**. Use a probe to clean the radial artery and follow it distally until it disappears between the two heads of the **first dorsal interosseous muscle**. Note that the **dorsal carpal arch** supplies arterial blood to the dorsum of the hand (Fig. 2.26), but do not dissect its branches.
6. Near the elbow, use your fingers to retract the brachioradialis muscle and observe the **supinator muscle.** The proximal attachments of the supinator muscle are the lateral epicondyle of the humerus, the radial collateral ligament, the anular ligament, and the lateral surface of the ulna. The distal attachment of the supinator muscle is the proximal one-third of the radius. The supinator muscle supinates the hand.
7. On the lateral aspect of the elbow, once again find the radial nerve in the connective tissue plane between the brachioradialis muscle and the brachialis muscle. Observe that the radial nerve divides into a superficial branch and a deep branch. The **deep branch of the radial nerve** enters the supinator muscle.
8. Turn the upper limb and look for the deep branch of the radial nerve where it emerges from the distal border of the supinator muscle.
9. When the deep branch of the radial nerve emerges from the supinator muscle, its name changes to **posterior interosseous nerve**. The posterior interosseous nerve provides motor branches to the extensor muscles.
10. Observe that the posterior interosseous nerve is accompanied by the **posterior interosseous artery**, which is a branch of the common interosseous artery.

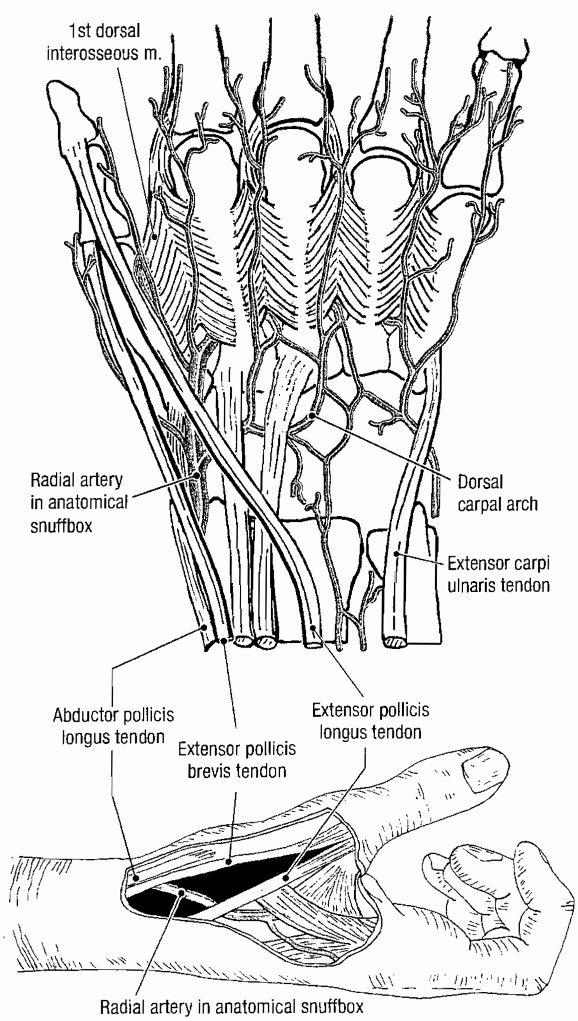


Figure 2.26. Radial artery in the anatomical snuffbox.

After you dissect . . .

Replace the muscles of the posterior compartment of the forearm into their correct anatomical positions. Use the dissected specimen to review the attachments of the extensor tendons. Note that the tendons of three strong extensor muscles (extensor carpi radialis longus, extensor carpi radialis brevis, and extensor carpi ulnaris) attach to the proximal ends of metacarpal bones. These three extensors of the wrist work synergistically with the flexors of the digits: a firm grasp requires an extended wrist. Review the extensor expansion of digit 3. Review the course of the common interosseous branch of the ulnar artery and observe how the posterior interosseous artery enters the posterior compartment of the forearm. Review the course of the radial artery from the cubital fossa to the deep palmar arch. Palpate the anatomical snuffbox on yourself. Feel the pulsations of the radial artery within its boundaries. Recall the rule for innervation of the posterior compartment of the forearm: **The radial nerve innervates all of the muscles in the posterior compartment of the forearm.** ***Note that there are no intrinsic muscles in the dorsum of the hand.***

JOINTS OF THE UPPER LIMB

Before you dissect . . .

ect joints in one upper limb. Keep the soft tissue structures of the other limb intact for review purposes.

The order of dissection will be as follows: the sternoclavicular and acromioclavicular joints will be dissected. The glenohumeral joint will be dissected. The elbow joint and radioulnar joints will be studied. The wrist joint will be dissected. Finally, the joints of the digits will be studied. During this dissection, the muscles of one limb will be removed. Take advantage of this opportunity to review the proximal attachment, distal attachment, innervation, and action of each muscle as it is removed.

Dissection Instructions

STERNOCLAVICULAR JOINT [G 486; N 402; C 93]

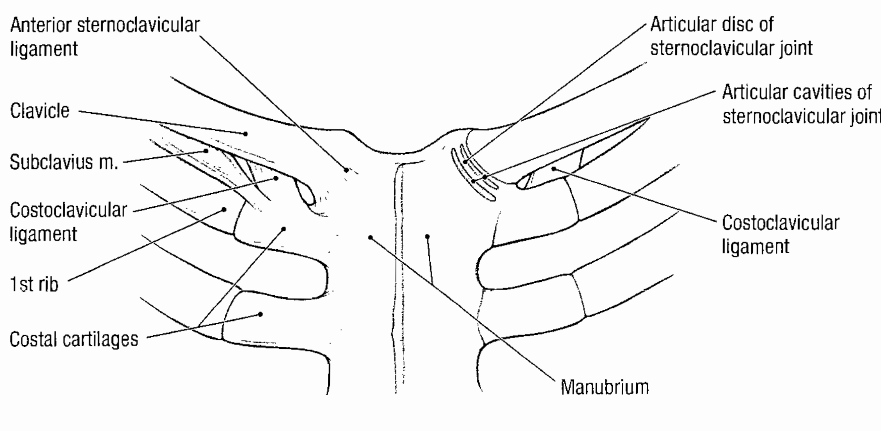
1. Use an articulated skeleton to observe the relationships between the sternum and clavicle. Identify the **clavicular notch of the manubrium.** The medial end of the clavicle articulates with the clavicular notch and the adjacent part of the first costal cartilage (Fig. 2.27).
2. Place the cadaver in the supine position. The tendon of the sternocleidomastoid muscle is attached to the anterior surface of the sternoclavicular joint. Detach the tendon and reflect the sternocleidomastoid muscle superiorly.
3. Identify the **anterior sternoclavicular ligament,** which connects the sternum to the clavicle.
4. Use blunt dissection to clean the **costoclavicular ligament,** which runs obliquely from the first costal cartilage to the inferior surface of the clavicle near its medial end.
5. Use a scalpel to remove the anterior sternoclavicular ligament. Within the joint cavity, observe the **articular disc.** Inferiorly, the articular disc is attached to the first costal cartilage. Superiorly, the articular disc is attached to the clavicle. Observe that the articular disc is attached in such a manner that it resists medial displacement of the clavicle.
6. Palpate the movements of the sternoclavicular joint on yourself. Place your left hand on your right sternoclavicular joint and circumduct your right upper limb through a large circle. Observe that the sternoclavicular joint allows a limited amount of movement in every direction.

ACROMIOCLAVICULAR JOINT [G 510, 512; N 406; R 366; C 72]

1. Review the bony features that are relevant to the **acromioclavicular joint: acromion, coracoid process of the scapula,** and **lateral end of the clavicle** (Fig. 2.28).
2. Detach the trapezius muscle from the lateral end of the clavicle. Detach the coracobrachialis and pectoralis minor muscles from the coracoid process. The acromioclavicular joint is now exposed. The acromioclavicular joint is a plane synovial joint between the acromion and the distal end of the clavicle.
3. Identify the **coracoclavicular ligament,** which supports the acromioclavicular joint. Use a probe to clean the ligament. Identify its two parts: **conoid ligament** and **trapezoid ligament.**
4. Open the acromioclavicular joint by completely removing the joint capsule. Separate the acromion from the lateral end of the clavicle.
5. Note the shape of the articulating surfaces. The angle of the articulating surfaces causes the acromion to move inferior to the distal end of the clavicle when the acromion is forced medially. The conoid and trapezoid ligaments prevent the acromion from moving inferiorly relative to the clavicle, strengthening the joint.

GLENOHUMERAL JOINT [G 510, 511; N 406; R 366; C 71-73]

The **glenohumeral joint (shoulder joint)** is a ball-and-socket synovial joint with a wide range of motion. The shoulder joint has a greater degree of movement than any other joint in the body. This is because of the small area of contact between the head of the humerus and the glenoid fossa of the scapula and the loose joint capsule. Stability of



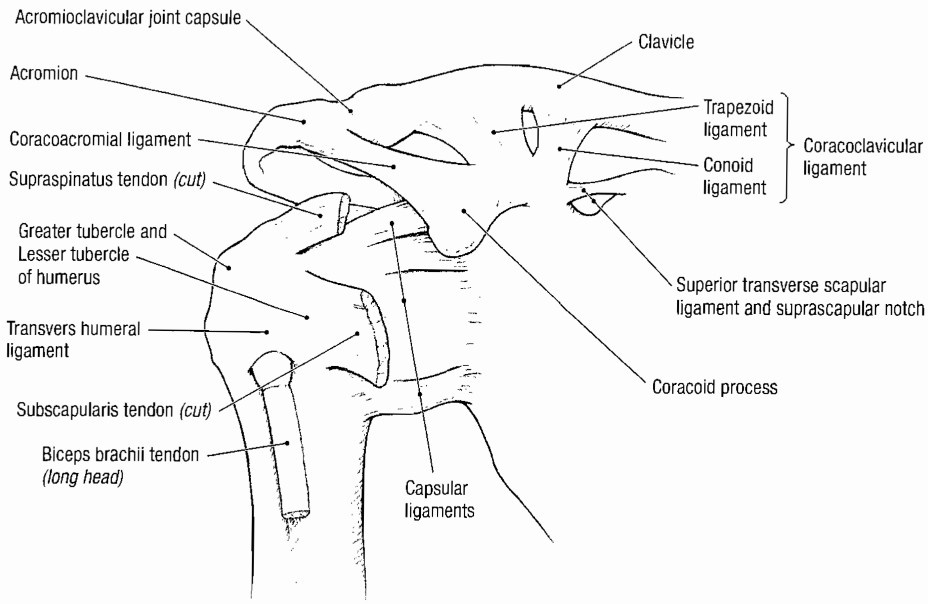


Figure 2.28. Acromioclavicular joint and anterior aspect of glenohumeral joint.

the shoulder joint depends on the function of the muscles of the rotator cuff.

1. Place the cadaver in the supine position.
2. Review the bony features pertinent to dissection of the **glenohumeral joint** (Fig. 2.29):
   - **Glenoid fossa of the scapula**
   - **Head of the humerus**
   - **Anatomical neck of the humerus**
3. To expose the **capsule of the glenohumeral joint**, the muscles and tendons that span the joint must be removed. Review the proximal attachment and distal attachment of each muscle as you remove it.
4. Remove the coracobrachialis muscle and the short head of the biceps brachii muscle. Leave the subscapularis muscle intact.
5. Place the cadaver in the prone position. Observe that the tendons of the supraspinatus, infraspinatus, and teres minor muscles blend with the joint capsule. Remove these tendons.
6. Remove the long head of the triceps brachii muscle
7. The posterior surface of the **joint capsule** is now exposed. Verify that the joint capsule is attached to the anatomical neck of the humerus.
8. Use a scalpel to open the posterior surface of the joint capsule (Fig. 2.29).
9. Use a saw or a chisel to remove the head of the humerus at the anatomical neck.
10. Use a probe to explore the **glenoid cavity**. Identify the **glenoid labrum** and attempt to demonstrate the three **glenohumeral ligaments**, which strengthen the anterior wall of the fibrous capsule (Fig. 2.29).
11. Observe that the **tendon of the long head of the biceps brachii muscle** passes through the glenoid cavity and is attached to the supraglenoid tubercle.
12. Place the cadaver into the supine position. Define and clean the **coracoacromial ligament**, which spans from the coracoid process to the acromion. The coracoacromial ligament, the acromion, and the coracoid process prevent superior displacement of the head of the humerus.

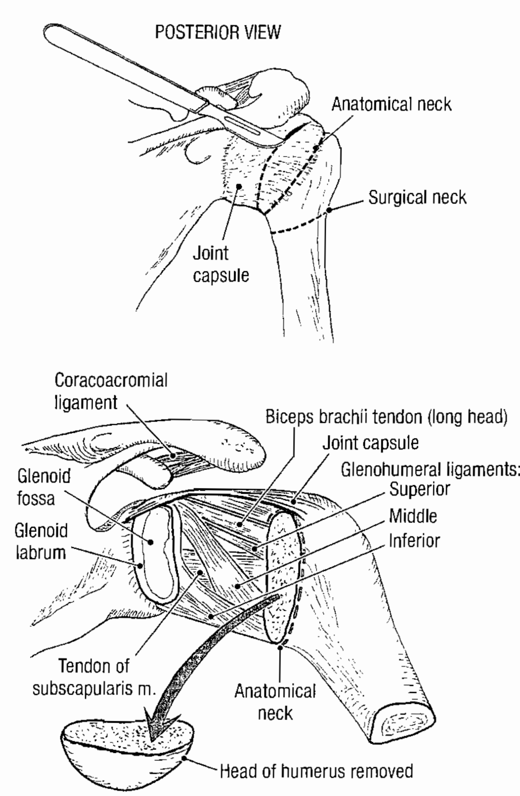


Figure 2.29. How to open the glenohumeral joint capsule and remove the head of the humerus.

13. Use the dissected specimen to perform the movements of the glenohumeral joint: Flexion, extension, abduction, adduction, and circumduction. Note that this freedom of motion is obtained at the loss of joint stability.

ELBOW JOINT AND PROXIMAL RADIOULNAR JOINT [G 526, 527; N 419, 421; R 367; C 80, 81]

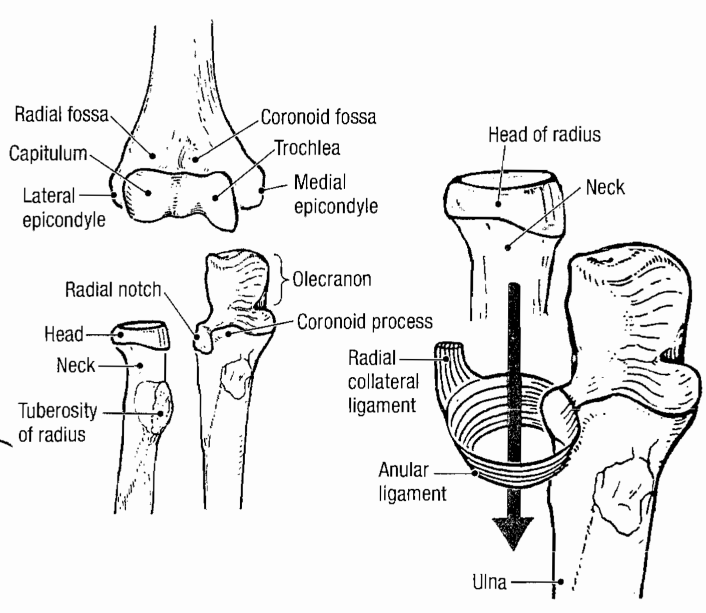
1. Review the bony features of the elbow region (Fig. 2.30).
2. Use an articulated skeleton to verify that the elbow joint consists of two parts:
   - A **hinge joint** between the trochlea of the humerus and the trochlear notch of the ulna.
   - A **gliding joint** between the capitulum of the humerus and the head of the radius.
3. Remove the brachialis muscle from the anterior surface of the joint capsule.
4. Detach the triceps brachii tendon from the olecranon and the posterior surface of the joint capsule.
5. Remove the superficial flexor muscles of the forearm from their attachment to the medial epicondyle. Review the common flexor tendon and the five muscles that attach to it.
6. Identify the **ulnar collateral ligament** on the medial side of the elbow joint (Fig. 2.30). Observe that it consists of a strong anterior cord and a fan-like posterior portion.
7. Remove the superficial extensor muscles of the forearm from their attachment to the lateral epicondyle of the humerus. Review the common extensor tendon and the muscles that attach to it.
8. Remove the supinator muscle.
9. Identify the **radial collateral ligament**. It fans out from the lateral epicondyle of the humerus to the radius and anular ligament.
10. The **proximal radioulnar joint** is a pivot joint that occurs between the head of the radius and the radial notch of the ulna. The **anular ligament** and the radial notch of the ulna completely encircle the head of the radius (Fig. 2.30). Note that the radius can freely rotate in the anular ligament. Place the hand of the cadaver specimen into the pronated position. Now, pull on the biceps brachii tendon. Note the strong supinating action of the biceps brachii muscle.
11. Open the elbow joint by making a transverse cut through the anterior surface of the joint capsule between the ulnar collateral ligament and the radial collateral ligament.
12. Use a probe to explore the extent of the **synovial cavity**. Observe the smooth articular surfaces of the humerus, ulna, and radius.
13. Use the dissected specimen to perform the movements of the elbow joint: flexion and extension. Observe the joint surfaces and the collateral ligaments during these movements.

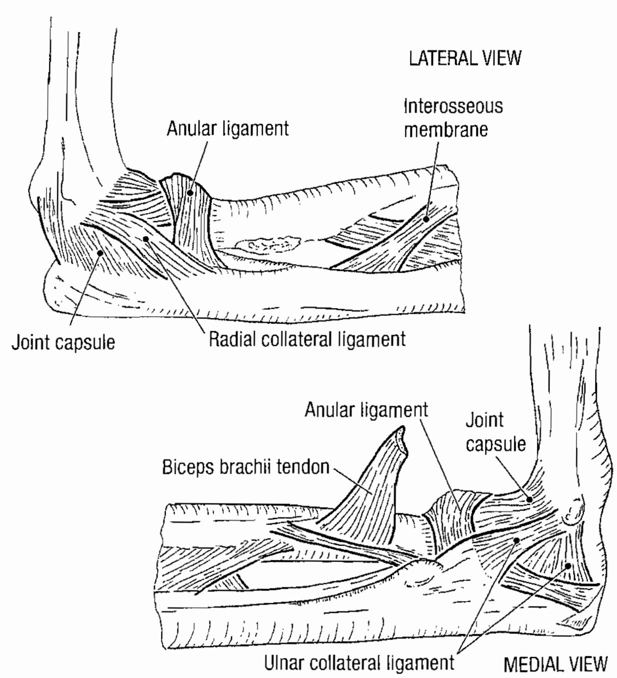
INTERMEDIATE RADIOULNAR JOINT [G 531; N 422; R 368; C 85]

1. The radius and ulna are joined throughout their length by the **interosseous membrane**. Use an illustration to study this joint.

DISTAL RADIOULNAR JOINT [G 570, 571; N 438; C 85]

1. The distal radioulnar joint is the pivot joint that occurs between the head of the ulna and the ulnar notch of the radius (Fig. 2.31).
2. Remove all tendons and soft tissue structures that cross the wrist. Review the distal attachment of each tendon and the action of each muscle.
3. Note that the anterior and posterior surfaces of the wrist joint are reinforced by **radiocarpal ligaments**.





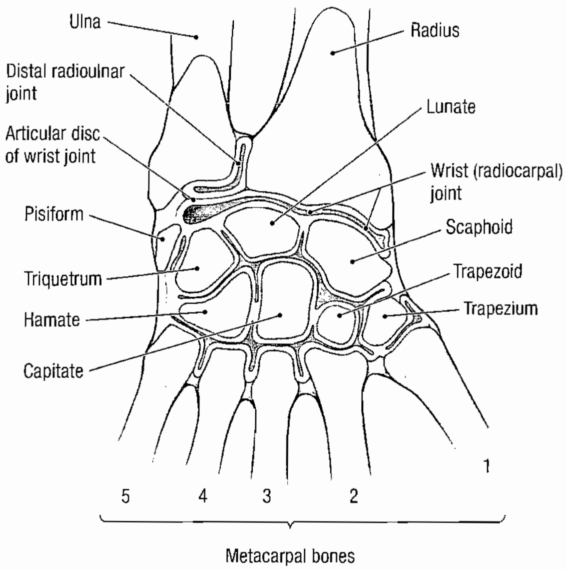


Figure 2.31. Distal radioulnar and wrist joints.

4. To open the distal radioulnar joint, extend the hand. On the anterior surface of the joint capsule, cut transversely through the radiocarpal ligaments. This cut should be made proximal to the flexor retinaculum and carpal tunnel. Leave the hand attached to the forearm by the posterior part of the joint capsule.
5. Use a probe to explore the articulation between the radius and the ulna. Note that the distal radioulnar joint contains an **articular disc**. Verify that the articular disc holds the distal ends of the radius and the ulna together.

WRIST JOINT [G 570, 572; N 437, 438; R 368, 369; C 84]

1. The **wrist joint (radiocarpal joint)** is the articulation between the distal end of the **radius** and the proximal **carpal bones** (Fig. 2.31). Note that the distal end of the radius articulates with only two carpal bones: **scaphoid** and **lunate**.
2. Identify the smooth proximal surfaces of the **scaphoid, lunate**, and **triquetrum**. Study the corresponding **articular surface of the radius.** Notice that the **scaphoid** and **lunate** bones must transmit forces from the hand to the forearm. Therefore, these carpal bones are the ones most commonly fractured in a fall on the outstretched hand.
3. Once again, identify the articular disc. The articular disc articulates with the triquetrum when the hand is adducted.
4. Use the dissected specimen to perform the movements of the wrist joint: flexion, extension, adduction, abduction, and circumduction. Observe the articular surfaces during these movements.

METACARPOPHALANGEAL JOINTS [G 575; N 441; R 369; C 85]

1. Dissect digit 3 as a representative example.
2. Remove the tendons of the flexor digitorum superficialis and flexor digitorum profundus muscles. Note their attachments on the phalanges.
3. Remove the interosseous muscles and the extensor expansion to expose the metacarpophalangeal joint capsule.
4. Clean the collateral ligaments (Fig. 2.32). Move the digit to confirm that the ligaments are slack during extension and taut during flexion. Therefore, the digits cannot be spread (abducted) unless they are extended.
5. Use the dissected specimen to perform the movements of the digit at the metacarpophalangeal joint: flexion, extension, abduction, and adduction. Confirm that the metacarpophalangeal joints are condyloid joints.

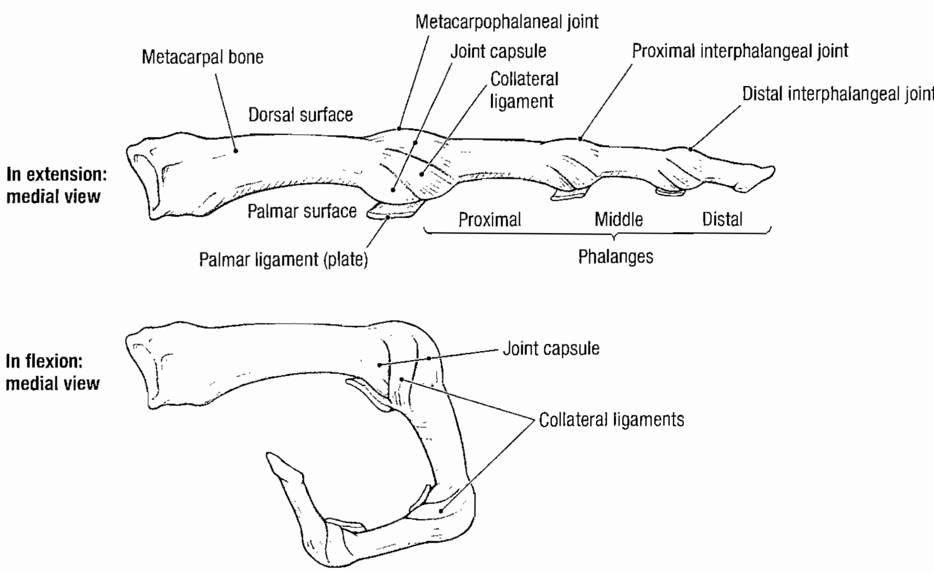


Figure 2.32. Metacarpophalangeal and interphalangeal joints.

INTERPHALANGEAL JOINTS [G 575; N 441; R 369; C 85]

1. Clean the collateral ligaments of the interphalangeal joints of digit 3 (Fig. 2.32).
2. Use a probe to explore the synovial cavity of one interphalangeal joint. Inspect the articular surfaces that are covered with smooth cartilage.
3. Use the dissected specimen to perform flexion and extension of the interphalangeal joint and confirm that the collateral ligaments limit the range of motion. Confirm that the interphalangeal joints are hinge joints.

CHAPTER 3
THE THORAX

The main function of the thorax is to house and protect the heart and lungs. The protective function of the thoracic wall is combined with mobility to accommodate volume changes during respiration. These two dissimilar functions, protection and flexibility, are accomplished by the alternating arrangement of the ribs and intercostal muscles.

The superficial fascia of the thorax contains the usual elements that are common to superficial fascia in all body regions: blood vessels, lymph vessels, cutaneous nerves, and sweat glands. In addition, the superficial fascia of the anterior thoracic wall in the female contains the mammary glands, which are highly specialized organs unique to the superficial fascia of the thorax.

SURFACE ANATOMY [G 2; N 174; C 2]

The surface anatomy of the thorax can be studied on a living subject or on the cadaver. Turn the cadaver to the supine position and palpate the following structures (Fig. 3.01):

- **Clavicle**
- **Acromion of the scapula**
- **Jugular notch (suprasternal notch)**
- **Manubrium**
- **Sternal angle**
- **Body of the sternum**
- **Xiphisternal junction**
- **Xiphoid process**
- **Seventh costal cartilage**
- **Costal margin**
- **Anterior axillary fold (lateral border of the pectoralis major muscle)**

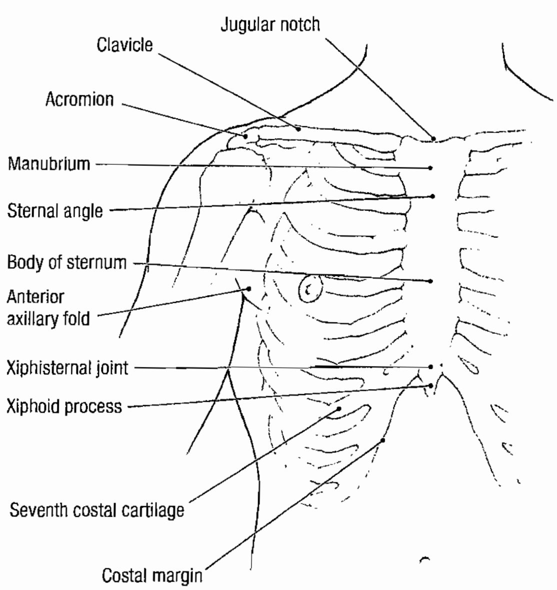


Figure 3.01. Surface anatomy of the anterior thoracic wall.

SKELETON OF THE THORAX

If you have previously dissected the back, review the parts of a **thoracic vertebra**. If you have not dissected the back, you must study the vertebrae now. Turn to pages 4–6, complete that exercise, and return to this page.

Refer to a skeleton. Examine a **rib** from the mid-thorax level and identify (Fig. 3.02): [G 13; N 179; R 191; C 96]

- **Head**
- **Neck**
- **Tubercle**
- **Angle**
- **Shaft (body)**
- **Costal groove**

On an articulated skeleton, note the following features:

- The **first rib** is the highest, shortest, broadest, and most curved of the ribs.
- The **head** of a rib usually articulates with two vertebral bodies and their intervertebral disc (the 1st, 10th, 11th, and 12th ribs are exceptions to this rule). For example, the head of rib 5 articulates with vertebral bodies T4 and T5 (Fig. 3.03).
- The **tubercle** of a rib articulates with the costal facet on the transverse process of the thoracic vertebra of the same number (Fig. 3.03).
- A **costal cartilage** is attached to the anterior end of each rib. Ribs are classified by the distal articulation of their costal cartilage:

True ribs (ribs 1–7) – costal cartilage is attached directly to the sternum.

False ribs (ribs 8–10) – costal cartilage is attached to the costal cartilage of the rib above.

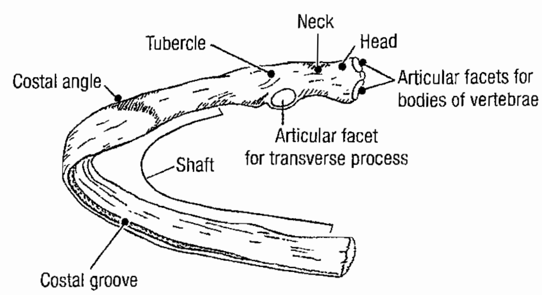


Figure 3.02. Typical left rib, posterior view.

KEY TO REFERENCES

G = Grant's Atlas, 11th ed., page number
N = Netter's Atlas, 3rd ed., plate number
R = Rohen's Color Atlas of Anatomy, 5th ed., page number
C = Clemente's Atlas, 4th ed., page number

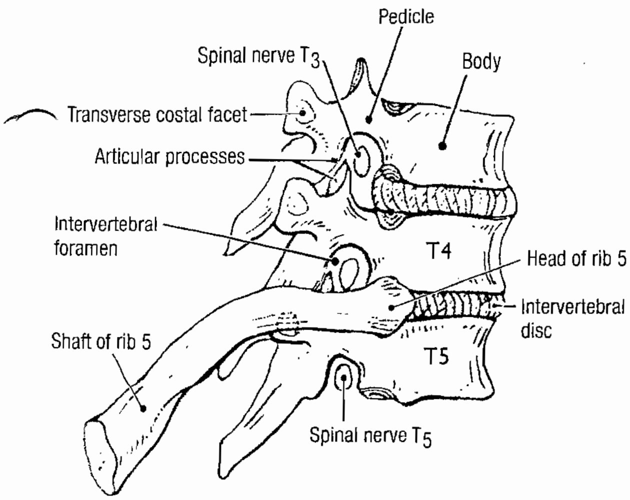


Figure 3.03. Part of the thoracic vertebral column.

Floating ribs (ribs 11 and 12) – costal cartilage is not attached to a skeletal element but ends in the abdominal musculature.

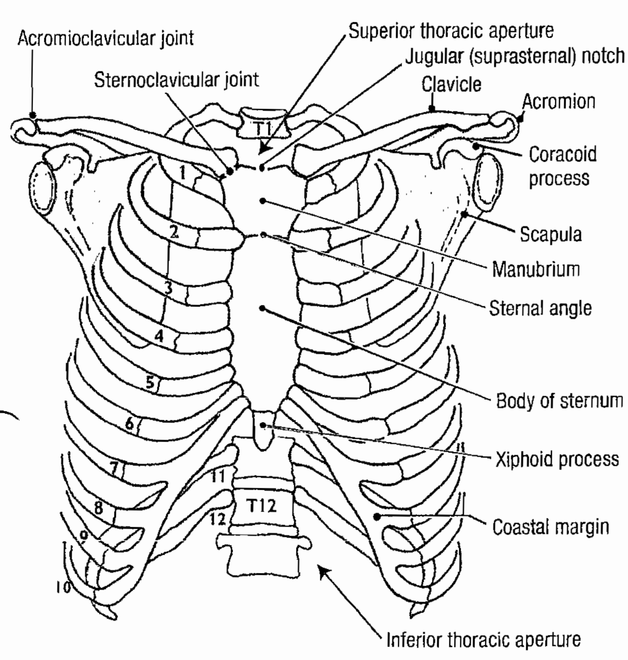
Examine the **sternum** and identify (Fig. 3.04): **[G 12; N 179; R 188; C 95]**

- **Jugular notch** (suprasternal notch)
- **Manubrium** (L. *manubrium*, handle)
- **Sternal angle** (at the level of the T4/T5 intervertebral disc; attachment of the second costal cartilage)
- **Body**
- **Xiphoid process** (Gr. *xiphos*, sword)

Examine a **scapula** and identify (Fig. 3.04): **[G 458; N 178; R 185; C 70]**

- **Acromion**
- **Coracoid process**

Observe that the medial end of the **clavicle** articulates with the manubrium of the sternum (**sternoclavicular joint**) and the lateral end of the clavicle articulates with the acromion of the scapula (**acromioclavicular joint**) (Fig. 3.04).



PECTORAL REGION

Before you dissect . . .

The **pectoral region** (L., *pectus*, chest) covers the anterior thoracic wall and part of the lateral thoracic wall. The order of dissection will be as follows: the skin will be removed from the thoracic wall, and the breast will be dissected in female cadavers. The superficial fascia will be removed.

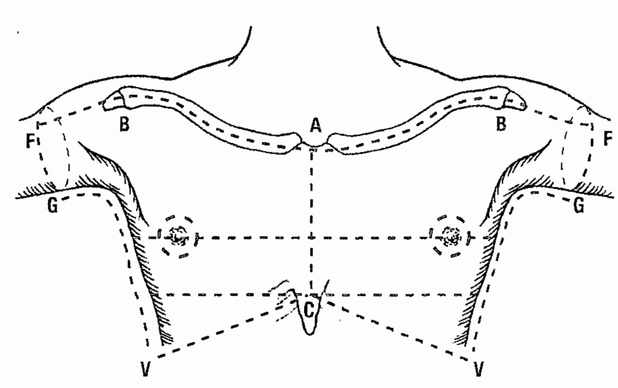
Dissection Instructions

SKIN INCISIONS

1. Place the cadaver in the supine position.
2. Refer to Figure 3.05. If the back has been dissected previously, some of these incisions have already been made. Before cutting, realize that the skin is thin on the anterior thoracic wall.
3. Make a midline skin incision from the jugular notch (A) to the xiphisternal junction (C).
4. Make a skin incision from the jugular notch (A) along the clavicle to the acromion (B), continuing to a point that is approximately halfway down the arm (F).
5. At point F, make an incision around the anterior and posterior surfaces of the arm, meeting on the medial side (G).
6. Make an incision from the xiphoid process (C) along the costal margin to the midaxillary line (V).
7. Make an incision that begins at G on the medial surface of the arm and extends superiorly to the axilla. Extend this incision inferiorly along the lateral surface of the trunk to V.
8. Make a transverse skin incision from the middle of the manubrium to the midaxillary line, passing around the nipple.
9. Make a transverse skin incision from the xiphisternal junction (C) to the midaxillary line.
10. Remove the skin from medial to lateral. Detach the skin along the midaxillary line and place it in the tissue container.

BREAST [G 4, 5; N 175; R 280; C 5]

The breast is dissected in female cadavers only. Students with male cadavers must observe at another dissection table. Because of the advanced age of some cadavers, it



may be difficult to dissect and identify all of the structures listed. Expect the lobes of the gland to be replaced by fat with advanced age.

The **breast** extends from the lateral border of the sternum to the midaxillary line, and from rib 2 to rib 6. The mammary gland is a modified sweat gland that is contained within the superficial fascia of the breast (Fig. 3.06). The breast is positioned anterior to the **pectoral fascia** (the deep fascia of the pectoralis major muscle). The pectoral fascia is attached to the overlying skin by the **suspensory ligaments of the breast** that pass between the lobes of the mammary gland.

1. Identify the **areola** and the **nipple** (Fig. 3.06).
2. Use the handle of a forceps to scoop the fat out of several compartments between **suspensory ligaments.** These areas between suspensory ligaments once contained lobes of functional glandular tissue.
3. Make a parasagittal (superior to inferior) cut through the nipple that divides the breast into a medial half and a lateral half (Fig. 3.06).
4. On the cut edge of the breast, use a probe to dissect through the fat deep to the nipple. Confine your search area to within 3 cm deep to the areola. Find and clean one of the 15 to 20 **lactiferous ducts** that converge on the nipple. Identify the **lactiferous sinus,** which is an expanded part of the lactiferous duct located deep to the nipple.
5. Trace one lactiferous duct to the nipple and attempt to identify its opening.
6. Use an illustration to study the **lymphatic drainage of the mammary gland. [G 9; N 177; R 280; C 6]**
7. Insert your fingers behind the breast and open the **retromammary space.** Note that the normal breast can be easily separated from the underlying deep fascia of the pectoralis major muscle.

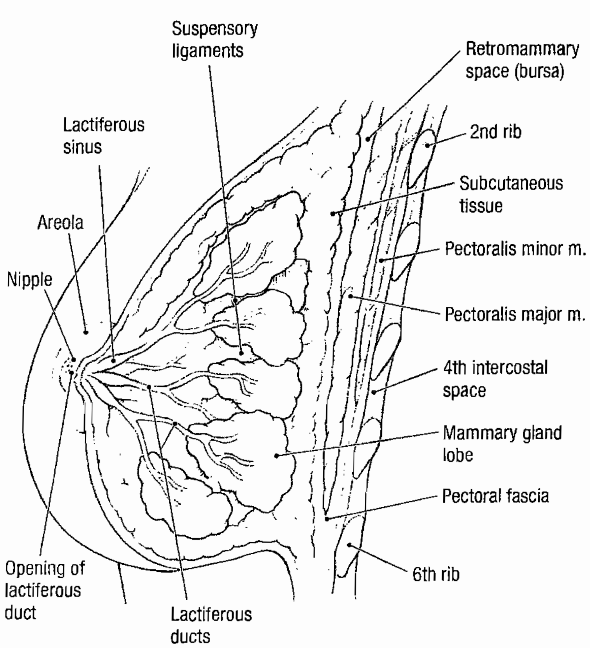


Figure 3.06. Breast in sagittal section.

8. Remove the breast from the anterior surface of the pectoralis major muscle with the aid of a scalpel.
9. Store the breast in a plastic bag.

CLINICAL CORRELATION

Breast

For descriptive purposes, clinicians divide the breast into four quadrants. The superolateral (upper outer) quadrant contains a large amount of glandular tissue and is a common site for breast cancers to develop. From this quadrant, an "axillary tail" often extends into the axilla.

In advanced stages of breast cancer, the tumor may invade the underlying pectoralis major muscle and its fascia. When this happens, the tumor and breast become fused to the chest wall, a condition that can be detected by palpation during a physical examination. As the breast tumor enlarges, it places traction on the suspensory ligaments, resulting in dimpling of the skin overlying the tumor.

SUPERFICIAL FASCIA

1. Dissection of the superficial fascia must be performed on both male and female cadavers.
2. The **platysma muscle** is a muscle of facial expression that may extend into the superficial fascia of the superior thorax. It is very thin, but broad. If the platysma muscle is present in the thorax, dissect it from the superficial fascia that lies deep to it and reflect it superiorly. Do not extend the dissection field superior to the clavicles.
3. Make a vertical cut through the superficial fascia in the midline of the sternum. Make additional cuts through the superficial fascia corresponding to skin incisions A to F, C to V, and G to V (Fig. 3.05).
4. Use blunt dissection to remove the superficial fascia, proceeding from medial to lateral.
5. Study an illustration of the **cutaneous branches of a typical spinal nerve**. The **anterior cutaneous branches** are small and emerge from the intercostal space lateral to the border of the sternum. Do not attempt to find them. **[G 20; N 187; R 204; C 7]**
6. As you peel back the superficial fascia, identify an intercostal space by palpation. Palpate the **lateral cutaneous branches** of the intercostal nerves where they leave the intercostal space and enter the superficial fascia. Identify one lateral cutaneous branch (from intercostal space 4, 5, or 6) while the superficial fascia is being removed. Trace its **anterior and posterior branches** for a short distance and preserve them.
7. Detach the superficial fascia along the midaxillary line and place it in the tissue container.

After you dissect . . .

Review the location and parts of the breast. Use an illustration to review the vascular supply to the breast. Discuss its pattern of lymphatic drainage and identify by name the lymph node groups that are involved. Use an illustration of the branching pattern of a typical spinal nerve to review the innervation of the anterior thoracic wall and breast.

MUSCLES OF THE PECTORAL REGION

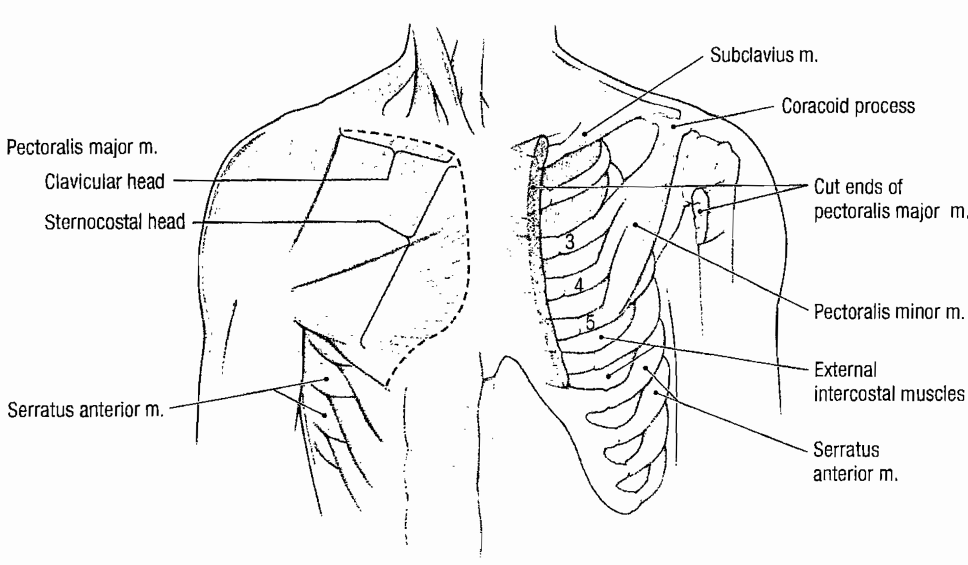
Before you dissect . . .

The muscles of the pectoral region attach the upper limb to the thoracic skeleton. Therefore, they are also known as the **anterior thoracoappendicular group of muscles**. The pectoral muscles are positioned immediately deep to the superficial fascia (deep to the breast).

The dissection will proceed as follows: the pectoralis major muscle will be studied and reflected. The pectoralis minor muscle and clavipectoral fascia will be studied. The pectoralis minor muscle will be reflected, and the branches of the thoraco-acromial artery will be dissected.

Dissection Instructions

1. Clean the superficial surface of the **pectoralis major muscle**, using your fingers to define its borders (Fig. 3.07). Study an illustration and note that the deep fascia on the surface of the pectoralis major muscle is called **pectoral fascia** and that it is continuous with the **axillary fascia** that forms the floor of the axilla. [G 478; N 407; R 394; C 11]
2. Identify the two heads of the pectoralis major muscle: **clavicular head** and **sternocostal head** (Fig. 3.07). Observe that the juncture of these two heads is at the sternoclavicular joint.
3. Use your fingers to trace the tendon of the pectoralis major muscle to its distal attachment on the humerus. The pectoralis major muscle flexes, adducts, and medially rotates the humerus.
4. Between the clavicular head of the pectoralis major muscle and the adjacent deltoid muscle, use blunt dissection to define the borders of the **deltopectoral triangle** and find the **cephalic vein**. Preserve the cephalic vein in subsequent steps of this dissection.
5. Relax the sternal head of the pectoralis major muscle by flexing and adducting the arm. Gently insert your fingers posterior to the inferior border of the pectoralis major muscle. Create a space between the posterior surface of the pectoralis major and the **clavipectoral fascia**. Push your fingers superiorly to open this space.
6. Use scissors to detach the sternal head of the pectoralis major muscle from its attachment to the sternum (dashed line, Fig. 3.07).
7. Palpate the deep surface of the pectoralis major muscle to locate the **medial and lateral pectoral nerves and vessels**. Preserve these nerves and vessels.
8. Use scissors to cut the clavicular head of the pectoralis major muscle close to the clavicle (Fig. 3.07). Preserve the cephalic vein. Note that the **lateral pectoral nerve** and the **pectoral branch of the thoraco-acromial artery** enter the deep surface of the clavicular head.
9. Reflect the pectoralis major muscle laterally. If the nerves and vessels of the pectoralis major muscle prevent reflection, cut a small piece (1 cm^2) out of the muscle and leave it attached to the nerves and blood vessels.
10. Deep to the pectoralis major muscle are the **clavipectoral fascia** and **pectoralis minor muscle**. [G 480; N 411; R 395]
11. Note that the **medial pectoral nerve** pierces the **pectoralis minor muscle**, then enters the sternal head of the pectoralis major muscle.
12. Read a description of the **clavipectoral fascia** and understand that it is attached to the clavicle. It passes both superficial and deep to the subclavius muscle and



the pectoralis minor muscle. The clavipectoral fascia is attached to the axillary fascia inferiorly.

13. Identify the **subclavius muscle**, which is located inferior to the clavicle (Fig. 3.07). The subclavius muscle, which is attached to the clavicle and the first rib, depresses the clavicle.
14. Clean the **cephalic vein** as it crosses the anterior surface of the pectoralis minor tendon. The cephalic vein passes through the **costocoracoid membrane** (part of the clavipectoral fascia) medial to the pectoralis minor tendon. The **thoraco-acromial artery** and the **lateral pectoral nerve** also pass through the costocoracoid membrane.
15. Use scissors to detach the pectoralis minor muscle from its proximal attachments on ribs 3-5 (Fig. 3.07).
16. Reflect the pectoralis minor muscle superiorly. Leave the muscle attached to the coracoid process of the scapula. **[G 480; N 410; R 398; C 13]**
17. Clean and define the branches of the thoraco-acromial artery (Fig. 3.08):
    - **Acromial branch** – passes laterally across the coracoid process to the acromion.
    - **Deltoid branch** – courses laterally in the **deltopectoral groove** between the deltoid muscle and pectoralis major muscle. The deltoid branch accompanies the cephalic vein.
    - **Pectoral branch** – passes between and supplies the pectoralis major muscle and the pectoralis minor muscle.
    - **Clavicular branch** – courses superiorly and medially to supply the subclavius muscle.
18. Along the lateral border of the pectoralis minor muscle, identify the origin of the **lateral thoracic artery** (Fig. 3.08). Do not follow the lateral thoracic artery at this time.
19. Identify the **serratus anterior muscle** (Fig. 3.07). Note its extensive proximal attachment on the upper eight ribs. The distal attachment of the serratus anterior muscle is the deep surface of the scapula along the entire length of its medial border. You cannot see the distal attachment at this time.
20. Do not disturb the contents of the axilla.

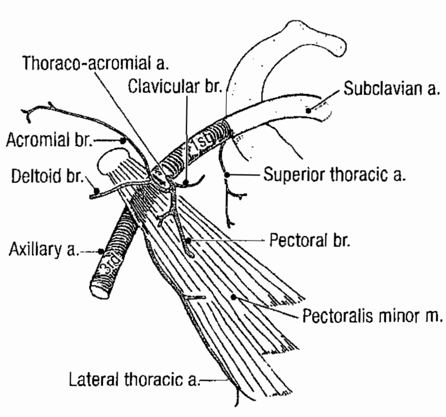


Figure 3.08. Blood supply to the pectoral region.

After you dissect . . .

Replace the pectoral muscles into their correct anatomical positions. Review the attachments of the pectoralis major and pectoralis minor muscles. Review their actions, innervations, and blood supply. Review the relationship of the clavipectoral fascia to the muscles, vessels, and nerves of this region. Name all branches of the thoraco-acromial artery and the structures supplied by each branch. Be sure that you understand the role played by the clavipectoral fascia in supporting the floor of the axilla.

INTERCOSTAL SPACE AND INTERCOSTAL MUSCLES

Before you dissect . . .

The interval between adjacent ribs is called the **intercostal space.** The intercostal space is only a space in a skeleton, because three muscles fill the intercostal space in the living body and the cadaver. From superficial to deep, the three muscles are the **external intercostal muscle**, the **internal intercostal muscle**, and the **innermost intercostal muscle**. There are 11 intercostal spaces on each side of the thorax. They are numbered corresponding to the rib above.

The order of dissection will be as follows: the external intercostal muscle will be studied in one intercostal space and reflected. The internal intercostal muscle will be studied and reflected. Branches of intercostal nerves and blood vessels will be identified. The innermost intercostal muscle will be identified.

Dissection Instructions

1. Detach the **serratus anterior muscle** from its proximal attachments on ribs 1 to 8 and reflect it laterally.
2. Palpate the ribs and the intercostal spaces. Begin at the level of the sternal angle (attachment of the second costal cartilage) and identify each intercostal space by number.
3. Dissect intercostal space 4 (the space between ribs 4 and 5).
4. Identify the **external intercostal muscle** (Fig. 3.09). The external intercostal muscle attaches to the inferior border of the rib above and the superior border of the rib below. The external intercostal muscle elevates the rib below. Note that the fibers of the external intercostal muscles pass diagonally toward the anterior midline as they descend. **[G 19; N 185; R 195; C 93]**
5. Identify the **external intercostal membrane**, which is located at the anterior end of the intercostal space between the **costal cartilages**. Note that the fibers of the external intercostal muscle end at the lateral edge of the external intercostal membrane.
6. Insert a probe deep to the external intercostal membrane just lateral to the border of the sternum in the fourth intercostal space. Push the probe laterally and note that it passes posterior to the external intercostal muscle.

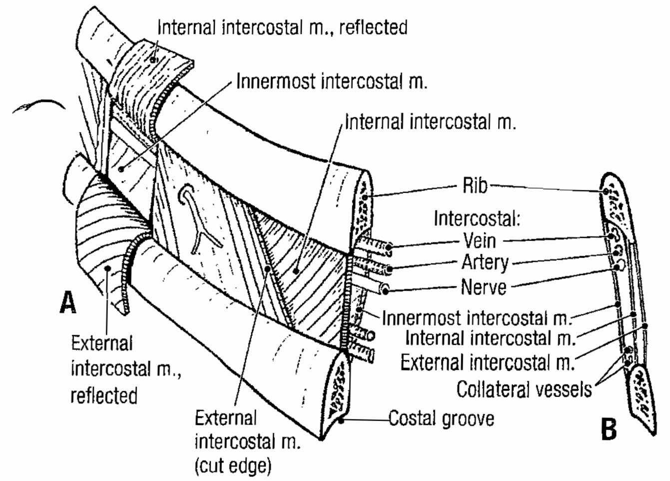


Figure 3.09. Structures in the intercostal space. **A.** Anterior view. **B.** Coronal section at the midaxillary line.

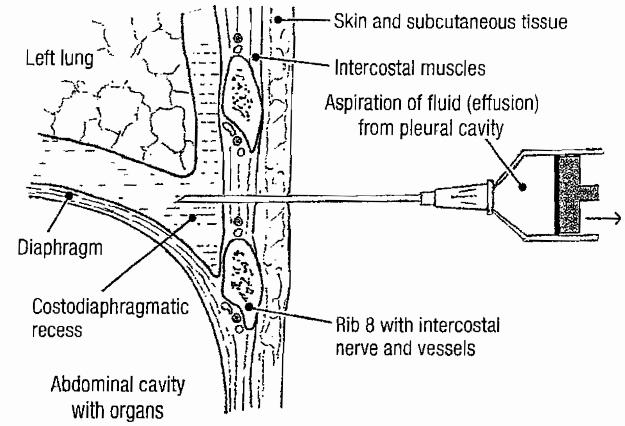


Figure 3.10. Anatomical relationships associated with a pleural tap.

7. With the probe as a guide, use scissors to cut the external intercostal muscle from the rib above and reflect it inferiorly. Continue the cut laterally to the midaxillary line.
8. Identify the **internal intercostal muscle.** The internal intercostal muscle attaches to the superior border of the rib below and the inferior border of the rib above. The internal intercostal muscle depresses the rib above. Note that the fiber direction of the internal intercostal muscle is perpendicular to the fiber direction of the external intercostal muscle (Fig. 3.09).
9. Begin at the midaxillary line and detach the internal intercostal muscle from its inferior attachment on rib 5. Reflect it superiorly. Continue to detach the internal intercostal muscle as far as the lateral border of the sternum.
10. Identify the fourth **intercostal nerve** and the fourth **posterior intercostal artery and vein** inferior to rib 4. The intercostal nerve and vessels run in the plane between the **internal intercostal muscle** and **innermost intercostal muscle** (Fig. 3.09). The **innermost intercostal muscle** has the same fiber direction, attachments, and action as the internal intercostal muscle, but it does not extend as far anteriorly in the intercostal space. **[G 20; N 187; R 204; C 7]**

CLINICAL CORRELATION

Pleural Tap (Thoracocentesis)

The aspiration of pathological material from the pleural cavity (serous fluid, fluid mixed with tumor cells, blood, pus, etc.) may be performed through the intercostal space. The pleural tap is performed in the midaxillary line or slightly posterior to it. Usually, intercostal space 6, 7, or 8 is selected for the puncture to avoid penetrating abdominal viscera. A large-bore needle is inserted low in the intercostal space to avoid injury to the intercostal nerve and vessels (Fig. 3.10).

11. The intercostal nerve and vessels supply the intercostal muscles, the skin of the thoracic wall, and the parietal pleura. Use an illustration to study their course and distribution.
12. The anterior end of the intercostal space is supplied by **anterior intercostal branches** of the **internal thoracic artery.** The internal thoracic artery runs a vertical course just lateral to the border of the sternum and crosses the deep surfaces of the costal cartilages. **[G 22; N 183; R 199; C 92]**

After you dissect . . .

Replace the internal and external intercostal muscles in their correct anatomical positions. Review the muscles that lie in the intercostal space. Review their actions. Understand how they assist respiration by elevating and depressing the ribs. Use an illustration and your dissected specimen to review the origin, course, and branches of the posterior intercostal artery and intercostal nerve. Consult a dermatome chart and compare the dermatome pattern to the distribution of the intercostal nerves. **[G 331; N 157; C 7]**

REMOVAL OF THE ANTERIOR THORACIC WALL

Before you dissect . . .

To open the thoracic cavity, the anterior thoracic wall must be reflected. The goal of this dissection is to reflect the thoracic wall with the underlying **costal parietal pleura.** The area to be reflected includes the anterior and lateral portions of ribs 1 through 5, the contents of the intercostal spaces, and the sternum.

The order of dissection will be as follows: the ribs and contents of the intercostal spaces will be cut at the midaxillary line. The clavicles will be cut. The costal cartilages and sternum will be cut. The anterior thoracic wall will be reflected superiorly, using the muscles of the lower neck as a hinge. The neck muscles will remain intact and will not be detached from their sternal and clavicular attachments. The inner surface of the thoracic

Dissection Instructions

1. Reflect the serratus anterior muscle laterally.
2. Cut both clavicles at their mid-length using a saw (Fig 3.11, cuts 1 and 2).
3. Make a transverse cut across the sternum and costal cartilages at the level of intercostal space 5 (Fig. 3.11, cut 3). Allow the saw to pass through the bone and cartilage, but not the deeper tissues.
4. Use a saw or bone forceps to cut ribs 1 to 5 in the midaxillary line on both sides of the thorax.
5. With a scalpel, cut intercostal spaces 1 to 5 in the midaxillary line. Make the cut deep enough to cut the parietal pleura.
6. Use scissors to cut the intercostal muscles and underlying parietal pleura from the upper border of rib 6 on both sides of the thorax.
7. Gently, elevate the inferior end of the sternum with the attached portions of the severed ribs, and identify the **right and left internal thoracic vessels** (Fig. 3.11). Cut the internal thoracic vessels at the level of the fifth sternocostal joint and reflect them with the thoracic wall.
8. Reflect the anterior thoracic wall superiorly. Cut the parietal pleura with scissors where it reflects from the inner surface of the thoracic wall to the mediastinum. Leave the anterior thoracic wall attached to the muscles of the neck. **[G 23; N 184; R 196; C 100]**
9. On the internal surface of the anterior thoracic wall, identify the **costal parietal pleura**. Use blunt dissection to remove the parietal pleura from the inner surface of the anterior thoracic wall.
10. Identify the **transversus thoracis muscle**. Observe that the inferior attachment of the transversus thoracis muscle is on the sternum and its superior attachment is on costal cartilages 2 to 6. The transversus thoracis muscle depresses the ribs.
11. The **internal thoracic vessels** are located between the costal cartilages and the transversus thoracis muscle. Observe that the internal thoracic artery divides into the **superior epigastric artery** and the **musculophrenic artery**. Identify at least one of the **anterior intercostal branches** of the internal thoracic artery.

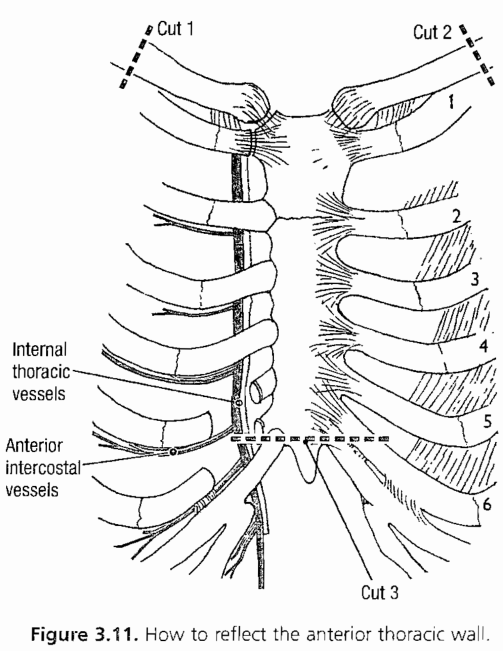


Figure 3.11. How to reflect the anterior thoracic wall.

After you dissect . . .

Replace the anterior thoracic wall in its correct anatomical position. Also replace the pectoralis minor muscle, making sure that its proximal attachments touch ribs 3, 4, and 5. Finally, replace the pectoralis major muscle in its original anatomical position. Review the attachments and the action of the pectoral muscles, the serratus anterior muscle, and the transversus thoracis muscle. Study the course of the internal thoracic artery from its origin to its bifurcation and name its branches.

CLINICAL CORRELATION

Anterior Thoracic Wall

The anterior and lateral approaches are the two most common surgical approaches to the contents of the thorax. In the anterior approach, the sternum is split vertically in the midline. This approach does not cross major vessels and allows good access to the heart. The incision through the sternum is closed with stainless steel wires. In the lateral approach, an intercostal space is incised to provide access to the lungs or to structures posterior to the heart.

PLEURAL CAVITIES

Before you dissect . . .

The thorax has two apertures (Fig. 3.04). The **superior thoracic aperture (thoracic inlet)** is relatively small and bounded by the manubrium of the sternum, the right and left first ribs, and the body of the first thoracic vertebra. Structures pass between the thorax, the neck, and the upper limb through the superior thoracic aperture (e.g., **trachea, esophagus, vagus nerves, thoracic duct, major blood vessels**).

The **inferior thoracic aperture (thoracic outlet)** is larger and bounded by the xiphisternal joint, the costal margin, ribs 11 and 12, and the body of vertebra T12. The **diaphragm** attaches to the structures that form the boundaries of the inferior thoracic aperture and separates the thoracic cavity from the abdominal cavity. Several large structures (e.g., **aorta, inferior vena cava, esophagus**) pass between the thorax and abdomen through openings in the diaphragm.

The thorax contains two **pleural cavities** (right and left) and the **mediastinum**. The two pleural cavities occupy the lateral parts of the thoracic cavity and each contains one **lung**. The mediastinum (L. *quod per medium stat*, that which stands in the middle) is the region between the two pleural cavities. It contains the **heart**, **aorta**, **trachea**, and **esophagus**. **[G 28; N 192; R 233; C 99]**

Each pleural cavity is lined by a serous membrane called the **parietal pleura** (Fig. 3.12). The parietal pleura has subdivisions that are regionally named:

- **Costal pleura**—lines the inner surface of the thoracic wall
- **Mediastinal pleura**—lines the mediastinum
- **Diaphragmatic pleura**—lines the superior surface of the diaphragm
- **Cervical pleura (cupula)**—extends superior to the first rib

The parietal pleura is sharply folded where the costal pleura meets the diaphragmatic pleura, and where the costal pleura meets the mediastinal pleura. The folds are called **lines of pleural reflection**. The lines of pleural reflection are acute, and the inner surfaces of the parietal pleurae are in contact with one another. The areas where parietal pleura contacts parietal pleura are called **pleural recesses**. The two **costomediastinal recesses** (left and right) occur posterior to the sternum where costal pleura meets mediastinal pleura. The two **costodiaphragmatic recesses** (left and right) are located at the most inferior limits of the parietal pleura (Fig. 3.12). During quiet inspiration, the inferior border of the lung does not extend into the costodiaphragmatic recess. **[G 28; N 192; R 255; C 101]**

The **endothoracic fascia** is a small amount of connective tissue between the thoracic wall and the costal parietal pleura. Endothoracic fascia provides a cleavage plane for surgical separation of the pleura from the thoracic wall.

Each lung is completely covered with **visceral pleura (pulmonary pleura)**. At the root of the lung, the visceral pleura becomes continuous with the mediastinal parietal pleura.

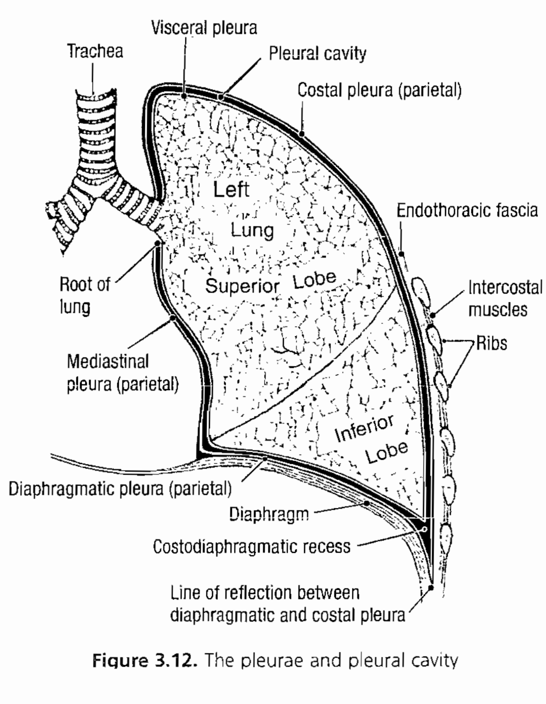


Figure 3.12. The pleurae and pleural cavity

Dissection Instructions

1. The **pleural cavity** is the space between the visceral pleura and the parietal pleura (Fig. 3.12). In the living body, the pleural cavity is a potential space and visceral pleura contacts parietal pleura.
2. Explore the right and left pleural cavities. *Caution: The ends of the ribs are sharp and can cut you.* To reduce the risk of injury, use a mallet or the side of the bone forceps to hit and blunt the ends of ribs 1 to 5. As an additional precaution, place paper towels over the cut ends of the ribs before you begin to palpate the pleural cavities.

CLINICAL CORRELATION

Pleural Cavity

Under pathological conditions, the potential space of the pleural cavity may become a real space. For example, if air enters the pleural cavity (pneumothorax), the lung collapses because of the elasticity of its tissue.

Excess fluid may accumulate in the pleural cavity, compress the lung, and produce breathing difficulties. The fluid could be serous fluid (plural effusion) or blood resulting from trauma (hemothorax).

3. Use paper towels or a large syringe to remove fluid that may have collected in the pleural cavity.
4. Identify the parts of the **parietal pleura**: **costal**, **diaphragmatic**, **mediastinal**, and **cervical**. Part of the costal pleura was removed with the anterior thoracic wall.
5. Place your fingers in the **costodiaphragmatic recess**. Follow it posteriorly and notice the acute angle that the diaphragm makes with the inner surface of the thoracic wall.
6. Place your hand between the lung and the mediastinum and palpate the root of the lung. At the root of the lung the mediastinal parietal pleura is continuous with the visceral pleura. Palpate the **pulmonary ligament**, which extends inferior to the root of the lung.
7. The root of the lung is attached to the mediastinum. All other parts of the lung should slide freely against the parietal pleura. Pleural adhesions may occur between visceral and parietal pleurae. Pleural adhesions are the result of disease processes, and you should use your fingers to break them.

After you dissect . . .

Replace the anterior thoracic wall in is correct anatomical position. Use an illustration and the dissected specimen to project the lines of pleural reflection to the anterior thoracic wall. Review the course of the intercostal nerves and understand that they are the source of somatic innervation (including pain fibers) to the costal parietal pleura.

LUNGS

Before you dissect . . .

The order of dissection will be as follows: the surface features and relationships of the lungs that can be seen from an anterior view will be studied with the lungs in the thorax. Then, the lungs will be removed and the study of surface features and relationships of the lungs will be completed. The hilum of the lung will be studied.

Dissection Instructions

LUNGS IN THE THORAX

1. Observe the lungs *in situ* (Fig. 3.13). **[G 25; N 194; R 258; C 101]**
2. Each lung has three surfaces: **costal, mediastinal**, and **diaphragmatic**. You can see only the costal surface with the lung *in situ*.
3. Observe the **oblique fissure** on both lungs. Replace the anterior thoracic wall and observe that the oblique fissure lies deep to the fifth rib laterally and that it is deep to the sixth costal cartilage anteriorly. Clinicians may refer to the oblique fissure as the **major fissure**.
4. Lift the anterior thoracic wall and identify the **horizontal fissure** on the right lung. Replace the anterior thoracic wall and observe that the horizontal fissure lies deep to the fourth rib and fourth costal cartilage. Clinicians may refer to the horizontal fissure as the **minor fissure** or **transverse fissure**.
5. Note that the right lung has three lobes (**superior, middle**, and **inferior**). The left lung has two lobes (**superior** and **inferior**).
6. Observe that the **apex** of the lung rises as high as the neck of the first rib, superior to the body of the first rib. Therefore, the apex of the lung lies superior to the plane of the superior thoracic aperture and is actually in the neck.
7. Identify the **pericardium** that occupies the midline between the lungs. The pericardium contains the heart.

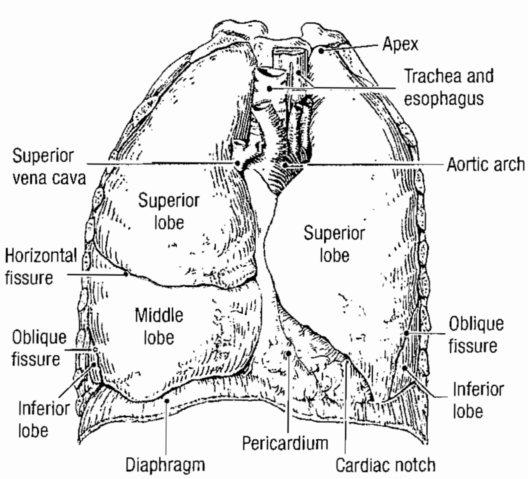


Figure 3.13. The lungs *in situ*.

8. Palpate the **root of the lung**. Feel the hard structures within the root of the lung. These are the pulmonary vessels, filled with clotted blood, and the main (primary) bronchus.
9. Observe that the **phrenic nerve** and **pericardiacophrenic vessels** pass anterior to the root of the lung and medial (deep) to the mediastinal pleura. Use an illustration to observe that the **vagus nerve** passes posterior to the root of the lung. **[G 78, 79; N 226, 227; R 270, 271; C 115, 117]**

REMOVAL OF THE LUNGS

1. Preserve the phrenic nerve, pericardiacophrenic vessels, and the vagus nerve during lung removal.
2. Place your hand into the pleural cavity between the lung and mediastinum. Retract the lung laterally, to stretch the root of the lung.
3. While retracting the lung, use scissors to transect the root of the lung halfway between the lung and the mediastinum. Take care not to cut into the mediastinum or the lung. Remove both lungs.
4. Compare the two lungs (Fig. 3.14). Note that the right lung is shorter but has greater volume than the left lung. **[G 32; R 239; C 106]**
5. Identify the **surfaces of the lung: costal, mediastinal**, and **diaphragmatic**.
6. Identify the **borders of the lung: anterior, posterior**, and **inferior**.
7. Recall that each lung has a **superior lobe** and an **inferior lobe** separated by the **oblique fissure**. Observe the lung from the lateral view, and note that most of the inferior lobe lies posteriorly and that most of the superior lobe lies anteriorly (Fig. 3.14).
8. Recall that the right lung has a **horizontal fissure**, which defines a small **middle lobe** (Fig. 3.14). Identify the middle lobe.
9. Identify the **cardiac notch** on the superior lobe of the left lung (Fig. 3.14). The cardiac notch is located on the anterior border of the left lung, anterior to the heart.
10. Identify the **lingula** of the left lung. The lingula is the inferior, medial portion of the superior lobe of the left lung.
11. Identify **contact impressions** on the mediastinal surface of each lung (Fig. 3.15). These impressions are artifacts of embalming and illustrate the close proximity of the mediastinal structures to the lung.
    - On the mediastinal surface of the **right lung**, identify the **cardiac impression**, the **groove for the esophagus**, the **groove for the arch of the azygos vein**, and the **groove for the superior vena cava.**
    - On the mediastinal surface of the **left lung**, identify the **cardiac impression**, the **groove for the aortic arch**, and the **groove for the thoracic aorta.** **[G 34, 35; N 195; R 239; C 108]**
12. Examine the **hilum of the lung**. Identify the **main bronchus, pulmonary artery**, and **pulmonary veins.** At the hilum, the main bronchus usually lies posterior to the pulmonary vessels, and the pulmonary artery is superior to the pulmonary veins (Fig. 3.15). To help

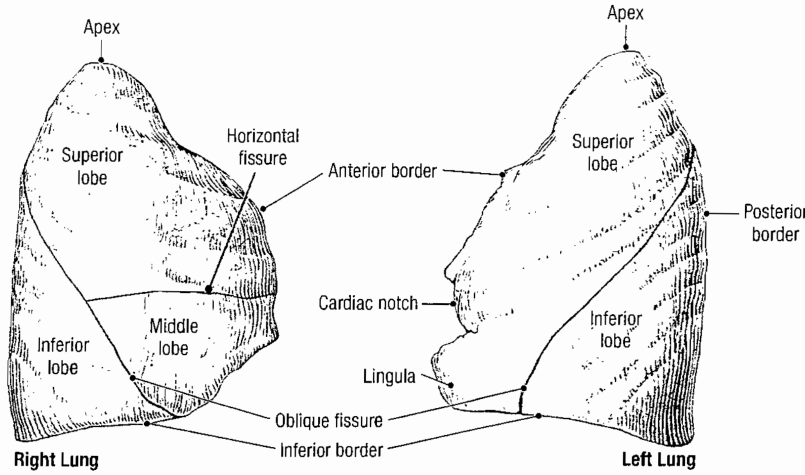


Figure 3.14. Lateral view of the lungs.

distinguish the artery from the veins, compare the relative thickness of the walls of the vessels (arteries have thicker walls).

13. At the hilum of each lung, use blunt dissection to follow the **main bronchus** into the lung.
14. In the left lung, identify the **superior** and **inferior lobar (secondary) bronchi. [G 41; N 199; R 237; C 110]**
15. In the right lung, identify the **superior**, **middle**, and **inferior lobar bronchi**. Note that the **right superior lobar bronchus** passes superior to the right pulmonary artery and it is named the "**eparterial bronchus.**"
16. Use blunt dissection to follow one lobar bronchus deeper into the lung (approximately 3 cm) until it branches into several **segmental bronchi**. Each lung contains 10 segmental bronchi, and each segmental bronchus supplies one **bronchopulmonary segment** of the lung. In your textbook, find a description of the bronchopulmonary segments and the internal organization of the lung.
17. Identify one of the **bronchial arteries**. The bronchial arteries are branches of the thoracic aorta that course along the surface of the main bronchus. The lumen of the bronchial artery can be seen where the main bronchus was cut during lung removal.
18. The hilum of the lung contains lymph nodes, lymph vessels, and autonomic nerve fibers. Use an illustration to confirm this. **[G 42, 43; N 204, 205; R 265; C 151]**
19. Note that the lungs have a rich nerve supply via the anterior and posterior pulmonary plexuses. Sympathetic contributions are received from the right and left sympathetic trunks, while parasympathetic contributions are received from the right and left vagus nerves.

After you dissect . . .

Review the parts of the lungs. Replace the lungs in their correct anatomical positions within the pleural cavities. Review the relationships of the phrenic and vagus nerves to the root of the lung. Replace the anterior thoracic wall. Project the borders, surfaces, and fissures of the lungs to the surface of the thoracic wall. Review the relationship of the pleural reflections to the thoracic wall. Review the costomediastinal and costodiaphragmatic recesses.

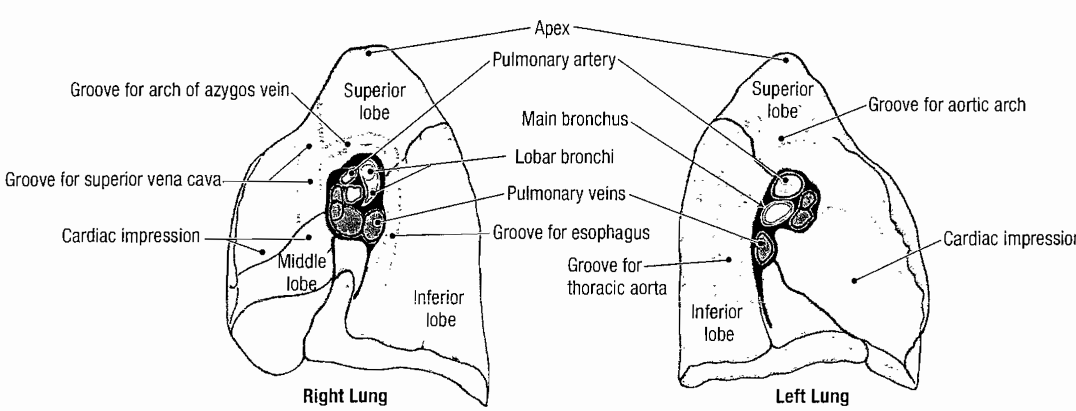


Figure 3.15. Mediastinal surface of the lungs.

MEDIASTINUM

Before you dissect . . .

The region between the two pleural cavities is the mediastinum. The **boundaries of the mediastinum** are:

- **Superior boundary** – superior thoracic aperture
- **Inferior boundary** – diaphragm
- **Anterior boundary** – sternum
- **Posterior boundary** – bodies of vertebrae T1 to T12
- **Lateral boundaries** – mediastinal parietal pleura (left and right)

For descriptive purposes, the mediastinum is divided into four parts (Fig. 3.16). An imaginary horizontal plane at the level of the sternal angle (**plane of the sternal angle**) intersects the intervertebral disk between vertebrae T4 and T5. The plane of the sternal angle separates the **superior mediastinum** from the **inferior mediastinum**. The pericardium divides the inferior mediastinum into three parts: **[G 29; R 233; C 118]**

- **Anterior mediastinum** – the part that lies between the sternum and the pericardium. In children and adolescents, part of the thymus may be found in the anterior mediastinum.
- **Middle mediastinum** – the part that contains the pericardium, the heart, and the roots of the great vessels.
- **Posterior mediastinum** – the part that lies posterior to the pericardium and anterior to the bodies of vertebrae T5 to T12. The posterior mediastinum contains structures that pass between the neck, thorax, and abdomen (esophagus, vagus nerves, azygos system of veins, thoracic duct, thoracic aorta).

Some structures that course through the mediastinum (esophagus, vagus nerve, phrenic nerve, thoracic duct) pass through more than one mediastinal subdivision. The **plane of the sternal angle** marks the level of the **superior border of the pericardium, bifurcation of the trachea**, and the **beginning and ending of the arch of the aorta.**

The order of dissection will be as follows: the mediastinal pleura will be examined and mediastinal structures will be palpated. The costal and mediastinal pleurae will then be removed.

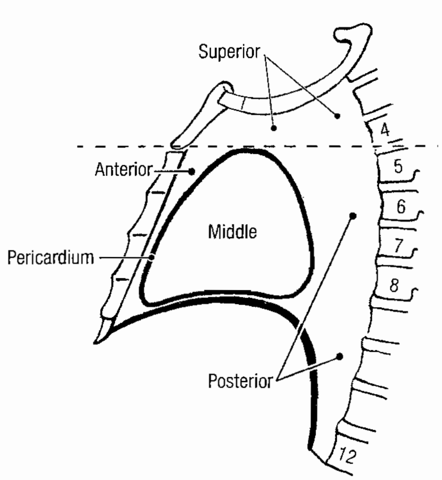


Figure 3.16. Subdivisions of the mediastinum.

Dissection Instructions

1. Observe the **mediastinal pleura**. You may be able to see structures through the mediastinal pleura. **[G 78, 79; N 226, 227; R 270, 271; C 115, 117]**
2. Palpate the **mediastinal pleura** from anterior to posterior. Observe that it is in contact with the **pericardium, root of the lung, esophagus (right side)**, and **thoracic aorta (left side)**.
3. Follow the mediastinal pleura further posteriorly until it sweeps laterally onto the sides of the vertebral bodies. At this location, the **mediastinal pleura** becomes the **costal pleura.**
4. To examine the mediastinum more closely, the parietal pleura must be removed bilaterally. Note that the **endothoracic fascia** provides a natural cleavage plane for separation of costal pleura from the thoracic wall.
5. Use your fingers to pick up the costal pleura at the cut ends of ribs 1 to 5. Peel the costal pleura off the inner surface of the posterior thoracic wall, moving from lateral to medial.
6. Continue to remove the parietal pleura where it covers the vertebral column, aorta, esophagus, and pericardium.
7. Identify the left and right **phrenic nerves** and the left and right **pericardiacophrenic vessels**. The phrenic nerve and pericardiacophrenic vessels are located between the mediastinal pleura and the pericardium approximately 1.5 cm anterior to the root of the lung. Follow the phrenic nerve and pericardiacophrenic vessels to the diaphragm. Each phrenic nerve is the only motor innervation to that half of the diaphragm.

MIDDLE MEDIASTINUM

Before you dissect . . .

The **middle mediastinum** contains the **pericardium**, the **heart**, and the **roots of the great vessels**. The **pericardium** is a sac that encloses the heart and it is pierced by the great vessels (aorta, pulmonary trunk, superior vena cava, inferior vena cava, and four pulmonary veins). The outer surface of the pericardium is fibrous, whereas the inner surface of the pericardium is serous and smooth. The pericardium is attached to the central tendon of the diaphragm. Thus, the heart moves with the diaphragm during inspiration and expiration.

The order of dissection will be as follows: the pericardium will be opened and its relationship to the heart and great vessels will be explored. The characteristics of the parietal serous pericardium will then be studied. The heart will be removed by cutting the great vessels.

Dissection Instructions

HEART IN THE THORAX [G 49; N 208; R 258; C 120]

1. Open the pericardium in the following manner (Fig. 3.17). Use forceps to elevate the anterior surface of the pericardium. Use scissors to make a longitudinal inci-

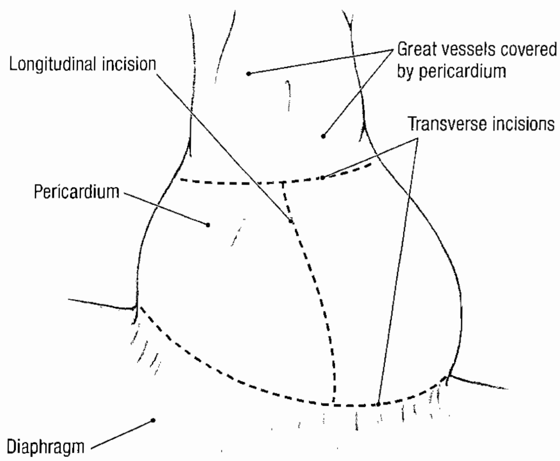


Figure 3.17. How to open the pericardium.

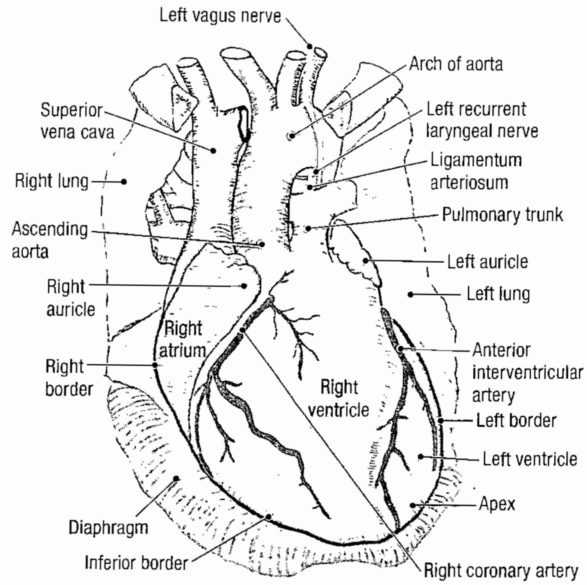


Figure 3.18. Anterior view of the heart *in situ*.

sion from the diaphragm to the aorta. Make the transverse incisions illustrated in Figure 3.17 and open the flaps widely.

2. Identify the following structures (Fig. 3.18): **superior vena cava, ascending aorta, arch of the aorta**, and **pulmonary trunk**.
3. Use your fingers to gently open the interval between the concavity of the aortic arch and pulmonary trunk, and identify the **ligamentum arteriosum** (Fig. 3.18). The ligamentum arteriosum connects the left pulmonary artery to the arch of the aorta.
4. Use a probe to dissect the **left vagus nerve** where it crosses the left side of the aortic arch (Fig. 3.18). Identify the initial portion of the **left recurrent laryngeal nerve**. The left recurrent laryngeal nerve is located inferior to the aortic arch and adjacent to the ligamentum arteriosum.
5. Examine the heart and identify the chambers that can be seen from the anterior view: **right atrium, right ventricle**, and **left ventricle** (Fig. 3.18). Note that the right ventricle forms the anterior part of the heart.
6. Identify the **borders of the heart**:
   - **Right border** – formed by the right atrium
   - **Inferior border** – formed by the right ventricle and a small part of the left ventricle
   - **Left border** – formed by the left ventricle
   - **Superior border** – formed by the right and left atria and auricles
7. Identify the **apex of the heart**. Note that the apex of the heart is part of the left ventricle. The apex of the heart is normally located deep to the left 5th intercostal space, approximately 9 cm from the midline.
8. Identify the **base of the heart**. The left atrium and part of the right atrium form the base of the heart, although clinicians refer to the emergence of the great vessels from the heart as its base.
9. Observe that the inner surface of the pericardium is lined by the smooth, shiny **parietal layer of serous pericardium**.
10. Use the cadaver and an illustration to observe that the parietal layer of serous pericardium is reflected onto the heart as the **visceral layer of serous pericardium (epicardium)**. The line of reflection of parietal serous pericardium to visceral serous pericardium occurs at the roots of the great vessels. **[G 49; N 208; R 259; C 120]**
11. The **pericardial cavity** is a potential space between the parietal layer and visceral layers of serous pericardium. Normally it contains only a thin film of serous fluid that lubricates the serous surfaces and allows free movement of the heart within the pericardium.
12. Place your right hand in the pericardial cavity with your fingers posterior to the heart. Lift the heart gently and push your fingers superiorly until they are stopped by the reflection of serous pericardium. Your fingertips are located in the **oblique pericardial sinus** (Fig. 3.19). Remove your hand from the oblique pericardial sinus. **[G 51; N 211; R 262; C 121]**
13. In the transverse plane, push your right index finger posterior to the pulmonary trunk and ascending aorta. Proceed from left to right and make your finger tip emerge between the superior vena cava and the aortic arch. Your finger is in the **transverse pericardial sinus** (Fig. 3.19).
14. Gently insert the tip of a probe between the pericardium and the anterior surface of the ascending aorta. Slowly advance the probe until it stops. This is the superior limit of the pericardial cavity.
15. Use your fingers to explore the lines of reflection of the serous pericardium where the great vessels (aorta, pulmonary trunk, superior vena cava, inferior vena

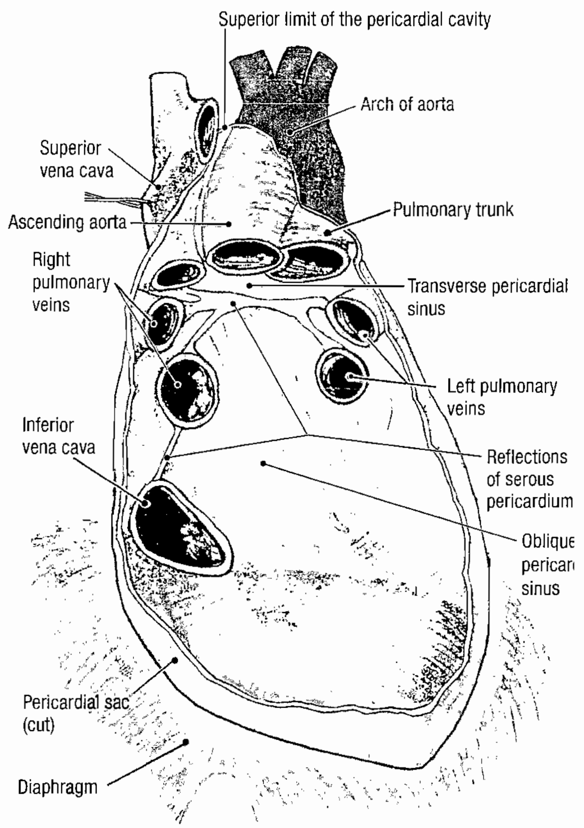


Figure 3.19. Inner surface of the posterior wall of the pericardium showing sinuses and serous reflections.

cava, and four pulmonary veins) enter and exit the heart (Fig. 3.19).

16. Replace the anterior thoracic wall into its correct anatomical position. Use the cadaver and an illustration to project the outline of the heart to the surface of the thoracic wall. **[G 26; N 192; R 242; C 99]**

CLINICAL CORRELATION

Pericardium

Inflammatory diseases can cause fluid to accumulate in the pericardial cavity (pericardial effusion). Bleeding into the pericardial cavity (hemopericardium) may result from penetrating heart wounds or perforation of a weakened heart muscle after myocardial infarction. Because the pericardium is composed of fibrous connective tissue, it cannot stretch, and fluids collected in the pericardial cavity compresses the heart (cardiac tamponade).

REMOVAL OF THE HEART

1. The heart will be detached from the great vessels along the lines of reflection of the serous pericardium (Fig. 3.19).
2. Place a probe through the transverse pericardial sinus.
3. Use scissors to cut the **ascending aorta** and the **pulmonary trunk** anterior to the probe, approximately 1.5 cm superior to the point where the aorta and pulmonary trunk exit the heart.
4. Lift the apex of the heart and cut the **inferior vena cava** close to the surface of the diaphragm.
5. Use scissors to cut the **superior vena cava** approximately 1 cm superior to its junction with the right atrium.
6. Lift the apex of the heart superiorly. Use scissors to cut the **four pulmonary veins** where they form the boundary of the oblique pericardial sinus (Fig. 3.19). Cut the pulmonary veins very close to the parietal pericardium.
7. The heart is now held in place only by reflections of serous pericardium from its posterior surface (Fig. 3.19). Cut these reflections and remove the heart.
8. Refer to Figure 3.19. Examine the posterior aspect of the pericardium and identify the openings of the eight vessels and the lines of the pericardial reflections.

After you dissect . . .

Review the parts of the mediastinum and state their boundaries. Review the attachments of the pericardium to the diaphragm and to the roots of the great vessels. Review the embryonic origin of the transverse and oblique pericardial sinuses. Compare the structural and functional properties of parietal serous pericardium to the properties of parietal pleura.

EXTERNAL FEATURES OF THE HEART

Before you dissect . . .

Dissection of the heart will proceed in two stages. The external features of the heart will be studied, including its vascular supply. The internal features of the chambers of the heart will then be studied.

Dissection Instructions

SURFACE FEATURES

1. Examine the external surface of the heart. Identify the following: **[G 46, 47; N 210; R 242; C 122, 123]**
   - **Coronary (atrioventricular) groove (sulcus)**—it runs obliquely around the heart, separating the atria from the ventricles.
   - **Anterior interventricular groove (sulcus)** and the **posterior interventricular groove (sulcus)**. The interventricular grooves indicate the location of the interventricular septum. The interventricular grooves join the coronary groove at a right angle.

2. Identify the **surfaces of the heart**:
   - **Sternocostal (anterior) surface** – formed mainly by the right ventricle.
   - **Diaphragmatic (inferior) surface** – formed mainly by the left ventricle and a small part of the right ventricle.
   - **Pulmonary (left) surface** – formed mainly by the left ventricle. The pulmonary surface of the heart is in contact with the cardiac impression of the left lung.
3. On the surface of the heart, identify the chambers:
   - **Right atrium** and **right auricle**
   - **Right ventricle**
   - **Left ventricle**
   - **Left atrium** and **left auricle**
4. Examine the heart in superior view. Identify:
   - **Aorta** and **aortic valve**
   - **Pulmonary trunk** and **pulmonary valve**
   - **Superior vena cava**
5. Examine the diaphragmatic surface of the heart and identify the **inferior vena cava.**
6. Observe that the coronary groove and the interventricular grooves mark the boundaries of the four chambers of the heart. The cardiac veins and coronary arteries are located in the grooves.

CARDIAC VEINS [G 53; N 212; R 252; C 122, 123]

1. The **cardiac veins** course superficial to the **coronary arteries,** so they will be dissected first. The coronary groove and the interventricular grooves are filled with fat that must be removed to observe the vessels. Use blunt dissection to remove the fat. Scraping motions with the handle of a forceps usually yield good results.
2. Identify the **coronary sinus** on the diaphragmatic surface of the heart (Fig. 3.20). The coronary sinus is a dilated portion of the venous system of the heart that is located in the coronary groove. The coronary sinus is approximately 2 to 2.5 cm in length and opens into the right atrium. Its opening will be seen when the internal features of the right atrium are dissected.
3. Use a probe to clean the surface of the coronary sinus. Note that most veins of the heart are tributaries to the coronary sinus (Fig. 3.20).
4. Follow the coronary sinus superiorly in the coronary groove to the point where it receives the **great cardiac vein.**
5. Use blunt dissection to follow the great cardiac vein onto the sternocostal surface of the heart. The great cardiac vein courses from the apex of the heart toward the coronary sinus in the anterior interventricular groove.
6. In the posterior interventricular groove, identify the **middle cardiac vein** and trace it to the coronary sinus.
7. Near the inferior end of the coronary sinus, identify the **small cardiac vein.** Use a probe to dissect the small cardiac vein and follow it to the anterior surface of the heart where it courses along the inferior border of the heart.

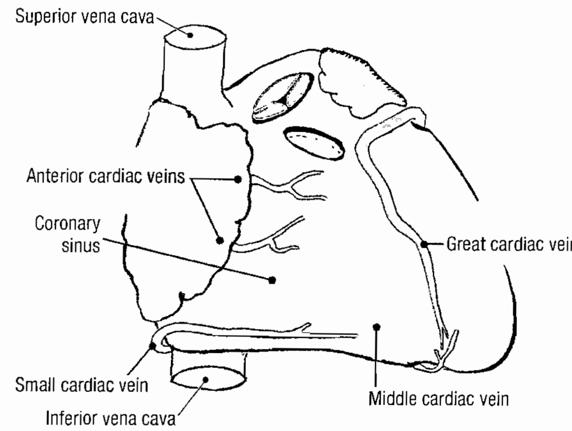


Figure 3.20. Cardiac veins.

8. **Anterior cardiac veins** bridge the atrioventricular groove between the right atrium and right ventricle. The anterior cardiac veins drain the anterior wall of the right ventricle directly into the right atrium. Anterior cardiac veins pass superficial to the right coronary artery.

CORONARY ARTERIES [G 52; N 212; R 252; C 126]

1. Begin the dissection of the coronary arteries by observing the superior surface of the **aortic valve.** Identify the **right, left,** and **posterior semilunar cusps** of the aortic valve. Behind each valve cusp is a small pocket called an **aortic sinus (right, left,** and **posterior,** respectively).
2. In the left aortic sinus, identify the **opening of the left coronary artery.** Place the tip of a probe into the opening. On the surface of the heart, palpate the tip of the probe between the left auricle and the pulmonary trunk. This is the initial portion of the left coronary artery.
3. Use blunt dissection to clean the left coronary artery. In the coronary groove, the left coronary artery divides into the **anterior interventricular branch** and the **circumflex branch** (Fig. 3.21).
4. Trace the **anterior interventricular branch** in the anterior interventricular groove to the apex of the heart. Clinicians call the anterior interventricular branch of

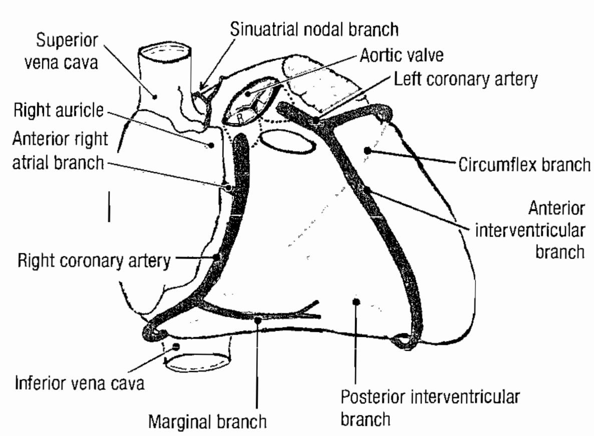


Figure 3.21. Coronary arteries and their branches.

the left coronary artery the Left Anterior Descending artery (**LAD**). Note that the anterior interventricular artery accompanies the great cardiac vein.

5. Follow the **circumflex branch of the left coronary artery** in the coronary groove and around the left border of the heart. The circumflex branch of the left coronary artery has several unnamed branches that supply the posterior wall of the left ventricle. The circumflex branch of the left coronary artery accompanies the coronary sinus in the coronary groove.
6. To begin the dissection of the **right coronary artery**, identify the **right semilunar cusp of the aortic valve** (Fig. 3.21). Insert a probe into the opening of the right coronary artery in the **right aortic sinus**. On the surface of the heart, palpate the tip of the probe in the coronary groove between the right auricle and the ascending aorta. This is the beginning of the right coronary artery.
7. Use blunt dissection to clean the right coronary artery and identify the **anterior right atrial branch** (Fig. 3.21). The anterior right atrial branch arises close to the origin of the right coronary artery and ascends along the anterior wall of the right atrium toward the superior vena cava. The anterior right atrial branch gives rise to the **sinuatrial nodal branch**, which supplies the sinuatrial node.
8. Follow the right coronary artery in the coronary groove. Preserve the anterior cardiac veins. The **marginal branch** of the right coronary artery usually arises near the inferior border of the heart. The marginal branch accompanies the small cardiac vein along the inferior border of the heart.
9. Continue to follow the right coronary artery in the coronary groove to the diaphragmatic surface of the heart. When the right coronary artery reaches the posterior interventricular groove, it gives rise to the **posterior interventricular branch**. The posterior interventricular branch courses along the posterior interventricular groove to the apex of the heart where it anastomoses with the anterior interventricular branch of the left coronary artery. The posterior interventricular branch accompanies the middle cardiac vein.
10. Note that the **artery to the atrioventricular node** arises from the right coronary artery at the point where the posterior interventricular groove meets the coronary groove.

CLINICAL CORRELATION

Coronary Arteries

In approximately 75% of hearts, the right coronary artery gives rise to the posterior interventricular branch and supplies the left ventricular wall and posterior portion of the interventricular septum. In approximately 15% of hearts, the left coronary artery gives rise to the posterior interventricular branch. Other variations account for 10%.

After you dissect . . .

Review the borders of the heart. On the surface of the heart, review the boundaries of the four chambers. Review the coronary groove and interventricular grooves of the heart and the vessels that course within these grooves. Trace a drop of blood from the right aortic sinus to the coronary sinus. Trace a drop of blood from the left aortic sinus to the apex of the heart and its venous return to the coronary sinus.

INTERNAL FEATURES OF THE HEART

Before you dissect . . .

The atria and ventricles of the heart will be opened and their internal features will be studied. The incisions that will be used are designed to preserve most of the vessels that you have previously dissected. The heart will contain clotted blood, which must be removed. The clots will be hard and may need to be broken before they can be extracted. The chambers will be dissected in the sequence that blood passes through the heart: **right atrium**, **right ventricle**, **left atrium**, and **left ventricle**. All descriptions are based on the heart in anatomical position.

Dissection Instructions

RIGHT ATRIUM [G 56; N 216; R 248; C 130]

1. The cuts used to open the right atrium are illustrated in Figure 3.22.
2. Use scissors to make a cut through the tip of the right auricle. Insert one blade of the scissors through the opening and make a short horizontal cut toward the right.
3. Turn the scissors and cut through the anterior wall of the right atrium in an inferior direction. Stop superior to the inferior vena cava.
4. Make a horizontal cut toward the left, stopping just short of the coronary groove.
5. Turn the flap of the atrial wall toward the left and open the right atrium widely (Fig. 3.23). Remove blood clots and take the heart to the sink to rinse it with water.
6. Observe the inner surface of the **anterior wall of the right atrium**. Identify (Fig. 3.23):
   - **Pectinate muscles** – horizontal ridges of muscle
   - **Crista terminalis** – a vertical ridge of muscle that connects the pectinate muscles

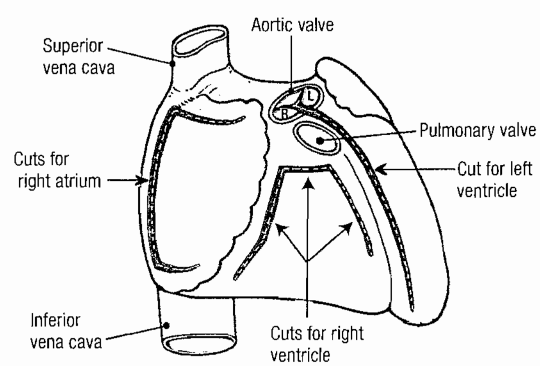


Figure 3.22. Cuts used to open the right atrium, right ventricle, and left ventricle of the heart.

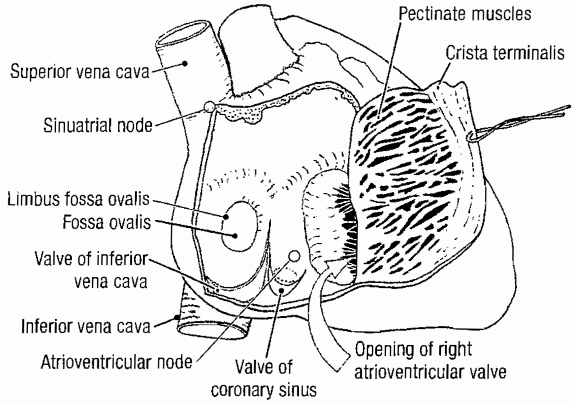


Figure 3.23. Interior of the right atrium. Approximate locations of the nodes of the conducting system are indicated.

7. Observe the **posterior wall of the right atrium.** Identify (Fig. 3.23):
   - **Opening of the superior vena cava**
   - **Opening and valve of the inferior vena cava**
   - **Opening and valve of the coronary sinus**
   - **Fossa ovalis** and the **limbus fossa ovalis** (L. *limbus*, a border)

CLINICAL CORRELATION

Fossa Ovalis

The **fossa ovalis** is the remnant of the **foramen ovale**. In fetal life, blood from the placenta is delivered to the heart by way of the inferior vena cava. This oxygen-rich and nutrient-rich blood is directed toward the foramen ovale, which allows passage into the left atrium and out to the body without entering the lungs.

8. Parts of the **conducting system of the heart** are located in the walls of the right atrium but cannot be seen in dissection. Familiarize yourself with their approximate locations in the dissected specimen (Fig. 3.23). The **sinuatrial node** (SA node) lies at the superior end of the crista terminalis at the junction between the right atrium and the superior vena cava. The **atrioventricular node** (AV node) is located in the lower part of the interatrial septum, near the opening of the coronary sinus.
9. Identify the opening of the **right atrioventricular valve,** which leads into the right ventricle.

RIGHT VENTRICLE [G 57; N 216; R 251; C 130]

1. The cuts used to open the right ventricle are illustrated in Figure 3.22.
2. Insert your finger into the pulmonary trunk and determine the level of the **pulmonary valve.** Inferior to the level of the pulmonary valve, use scissors to make a short horizontal cut through the **anterior wall of the right ventricle.**
3. Insert one blade of the scissors into the right end of the first cut and make a second cut parallel to the coronary groove. The second cut should be approximately 1 cm from the coronary groove and end at the inferior border of the heart. Cut only the ventricular wall, not the atrioventricular valve cusp.
4. Insert your finger through the opening and palpate the **interventricular septum.** From the left end of the first cut, make a third cut toward the inferior border of the heart. The third cut should be approximately 2 cm to the right of the anterior interventricular groove and should parallel the right side of the interventricular septum.
5. Turn the flap of the right ventricular wall inferiorly (Fig. 3.24).

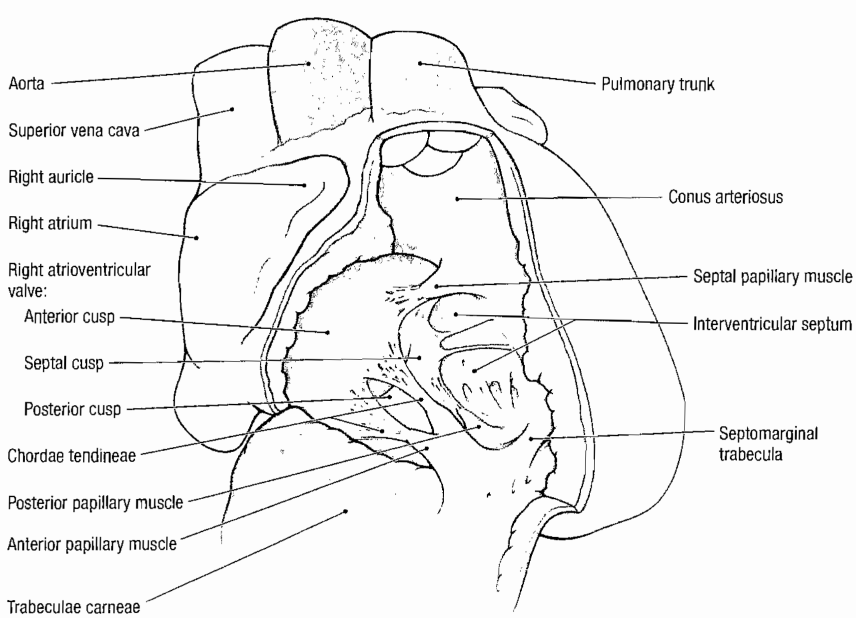


Figure 3.24. Interior of the right ventricle.

6. Remove blood clots. Use care to avoid damaging the **chordae tendineae**. Rinse the right ventricle with water.
7. Identify the **opening of the right atrioventricular valve**. Observe that the right atrioventricular valve has **three cusps: anterior, septal,** and **posterior** (Fig. 3.24). The right atrioventricular valve is also called the **tricuspid valve**.
8. Identify the **chordae tendineae.** Observe that these delicate tendons pass from the valve cusps to the apices of **papillary muscles**. The papillary muscles arise from the walls of the right atrium.
9. Identify **three papillary muscles: anterior, septal,** and **posterior**. The anterior papillary muscle is the largest and most prominent. The septal papillary muscle is very small and may be multiple. Note that the chordae tendineae of each papillary muscle attach to the adjacent sides of two valve cusps.
10. Observe that the inner surface of the wall of the right ventricle is roughened by muscular ridges called **trabeculae carneae** (L. *trabs*, wooden beam; *carneus*, fleshy).
11. Identify the **septomarginal trabecula (moderator band**). The septomarginal trabecula extends from the interventricular septum to the base of the anterior papillary muscle. The septomarginal trabecula contains part of the right bundle of the conducting system, the part that stimulates the anterior papillary muscle.
12. Identify the **opening of the pulmonary trunk** (Fig. 3.24). The **conus arteriosus (infundibulum)** is the cone-shaped portion of the right ventricle inferior to the opening of the pulmonary trunk. The inner wall of the conus arteriosus is smooth.
13. Observe that the **pulmonary valve** consists of **three semilunar cusps: anterior, right**, and **left. [G 60, 61; N 218; R 149; C 122]**
14. Look into the pulmonary trunk from above and examine the superior surface of the semilunar valve. Observe that each semilunar valve cusp has one fibrous **nodule** and two **lunules.** The nodule and lunules help to seal the valve cusps and prevent backflow of blood during diastole.

LEFT ATRIUM [G 58; N 217; R 248; C 132]

1. Examine the posterior surface of the heart. Observe the openings of the **four pulmonary veins** into the left atrium. The pulmonary veins are usually arranged in pairs, two from the right lung and two from the left lung.
2. The cut used to open the left atrium is illustrated in Figure 3.25A.
3. Use scissors to make an inverted, U-shaped incision through the posterior wall of the left atrium. Do not cut into the openings of the pulmonary veins; cut between them. Turn the flap inferiorly (Fig. 3.25B).
4. Remove blood clots and rinse with water.
5. Note that the inner surface of the wall of the left atrium is smooth except for its auricle, which has a rough inner surface.

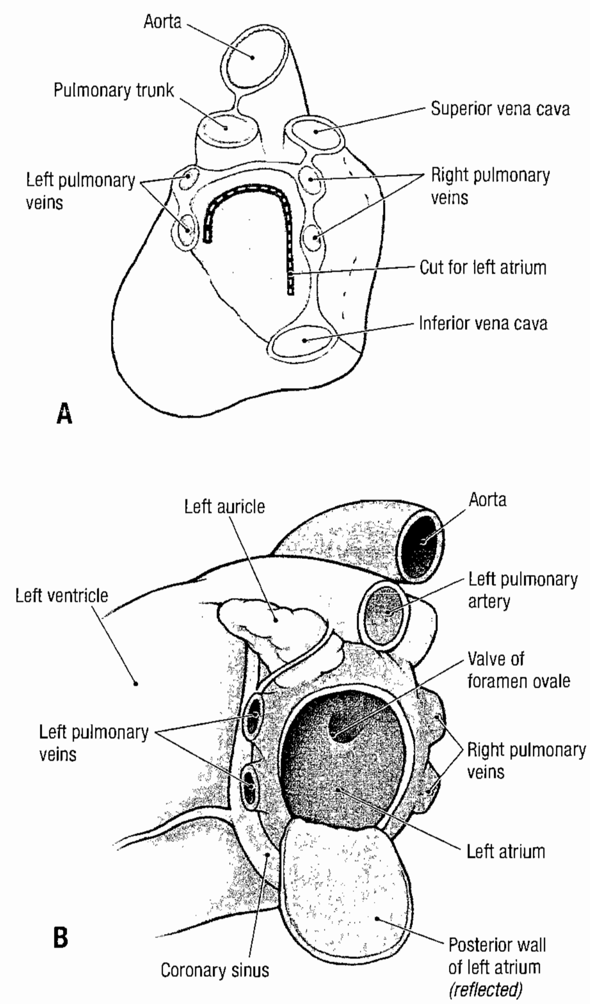


Figure 3.25. The left atrium of the heart. **A.** Cuts used to open the left atrium. **B.** Interior of the left atrium.

6. Observe the following features in the left atrium (Fig 3.25B):
   - **Valve of the foramen ovale** on the **interatrial septum**
   - **Opening into the left auricle**
   - **Opening of the left atrioventricular valve**

LEFT VENTRICLE [G 59; N 217; R 248; C 133]

1. The cut used to open the left ventricle is illustrated in Figure 3.22. Note that the following procedure will cut the anterior interventricular branch of the left coronary artery and the great cardiac vein.
2. Look into the aorta from above and identify the **aortic valve.** Identify **three semilunar valve cusps: right, left,** and **posterior. [G 60, 61; N 218, 219; R 249; C 122]**
3. Insert one blade of a scissors between the left and right semilunar cusps (Fig. 3.22).
4. Make a cut through the anterior wall of the ascending aorta between the left and right semilunar cusps. This cut should be anterior and parallel to the left coronary artery.

5. Continue the cut to the apex of the heart. The cut should be approximately 2 cm to the left of the anterior interventricular groove and should parallel the left side of the interventricular septum. The cut will cross the anterior interventricular branch of the left coronary artery and the great cardiac vein.
6. Open the left ventricle and the ascending aorta widely (Fig. 3.26). Remove blood clots and rinse with water.
7. In the left ventricle, identify the **left atrioventricular valve (bicuspid valve, mitral valve)**. Identify the **anterior cusp** and the **posterior cusp** (Fig. 3.26).
8. Identify the **anterior papillary muscle** and the **posterior papillary muscle**. Observe that the **chordae tendineae** of each papillary muscle attach to both valve cusps.
9. Observe that the inner surface of the wall of the left ventricle is roughened by **trabeculae carneae**.
10. Examine the **aortic valve**. Again identify its **right, left**, and **posterior semilunar cusps**. Observe that each semilunar valve cusp has one nodule and two lunules.
11. Palpate the **muscular part of the interventricular septum**. Place the thumb of your right hand in the right ventricle and your index finger in the left ventricle and palpate the thickness of the muscular part of the interventricular septum.
12. Move your thumb and index finger superiorly along the interventricular septum and identify the thin **membranous part of the interventricular septum**. It is located inferior to the attachment of the right cusp of the aortic valve.

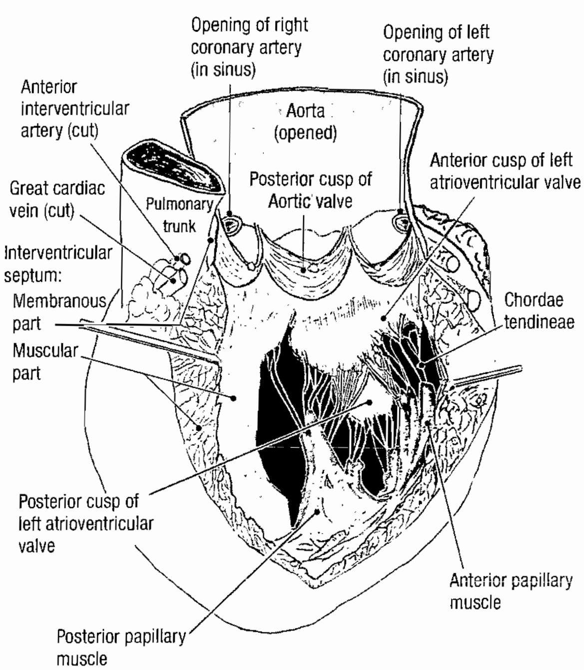


Figure 3.26. Interior of the left ventricle.

13. In the aorta, observe the openings of the **coronary arteries** and study their relationship to the semilunar valve cusps and the **aortic sinuses**. The posterior cusp is also called the **noncoronary cusp** because there is no coronary artery arising from its sinus.
14. Use an illustration to study the **conducting system of the heart**. Recall that the **sinuatrial (SA) node** is in the wall of the right atrium, at the superior end of the crista terminalis near the superior vena cava. Impulses from the SA node pass through the wall of the right atrium to the **atrioventricular (AV) node**. Impulses that originate in the AV node pass in the **atrioventricular (AV) bundle** through the membranous part of the interventricular septum. Subsequently, the AV bundle divides into **right and left bundles**, which lie on either side of the muscular part of the interventricular septum and stimulate the ventricles to contract. The right bundle is noteworthy because it carries impulses to the anterior papillary muscle through the **septomarginal trabecula. [G 62; N 221; R 251; C 136, 137]**

After you dissect . . .

Review the internal features of each of the chambers of the heart. Replace the heart into the thorax in its correct anatomical position. Return the thoracic wall to its anatomical position. Use an illustration, a textbook description, and the dissected specimen to project the heart valves to the surface of the anterior thoracic wall. Read a description of the auscultation point used to listen to each heart valve. Review the course of blood as it passes through the heart, beginning in the superior vena cava and ending in the ascending aorta. In the correct sequence, name all of the chambers and valves that the blood passes through. Review the blood supply to the heart. Trace a drop of blood from the left coronary artery and the right coronary artery to the coronary sinus, naming all vessels traversed. Review the connections of the great vessels to the heart. Use an illustration to review the conducting system of the heart and relate the illustration to the dissected specimen.

SUPERIOR MEDIASTINUM

Before you dissect . . .

The superior mediastinum contains structures that pass between the thorax and the neck, or the thorax and the upper limb. These structures include several of the great vessels and their primary branches, the trachea, the esophagus, and the thoracic duct.

The order of dissection will be as follows: the brachiocephalic veins will be studied and reflected. The aortic arch and its branches will be dissected. The trachea and its bifurcation will be studied. The upper part of the esophagus and the vagus nerves will be dissected. Note that only the proximal ends of some of the large vessels will be seen in this dissection. The distal parts of these vessels will be dissected with the neck or the upper limb.

Dissection Instructions

1. Study the **boundaries of the superior mediastinum** (Fig. 3.16).
   - **Superior –** superior thoracic aperture
   - **Posterior –** bodies of vertebrae T1 to T4:
   - **Anterior –** manubrium of the sternum
   - **Lateral –** mediastinal pleurae (left and right)
   - **Inferior –** plane of the sternal angle
2. Reflect the anterior thoracic wall superiorly.
3. Identify the **thymus**. In the adult, the thymus is a fatty remnant that lies immediately posterior to the manubrium of the sternum. **[G 64-67; N 208; R 259; C 119]**

CLINICAL CORRELATION

Thymus

In the newborn, the thymus is an active lymphatic organ that can be visualized on a chest radiograph. The thymus is replaced by connective tissue and fat after puberty. It may be difficult to recognize the thymus in the cadaver.

4. Remove the remnant of the thymus by blunt dissection.
5. Trace the superior vena cava superiorly until it bifurcates. Identify the **left brachiocephalic vein** (Fig. 3.27). Clean the anterior surface of the left brachiocephalic vein and free it from the structures that lie posterior to it.

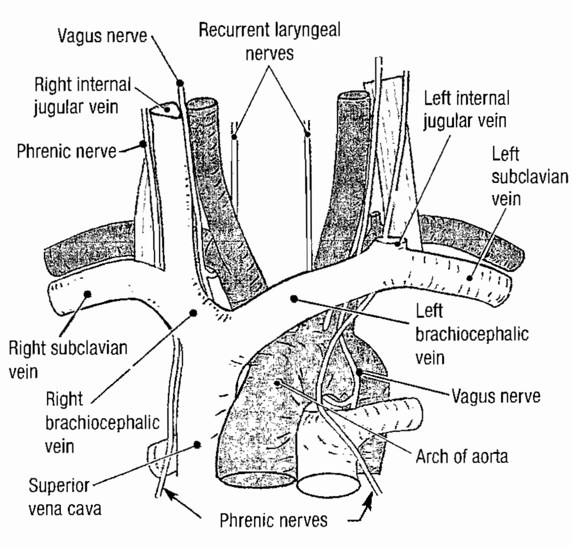


Figure 3.27. Relationships of the phrenic nerves and the vagus nerves to the great vessels.

6. Identify the **right brachiocephalic vein.** The two **brachiocephalic veins** meet to form the **superior vena cava** posterior to the inferior border of the right first costal cartilage.
7. Follow the superior vena cava inferiorly. Note that the superior vena cava passes anterior to the root of the right lung. **[G 78; N 226; R 270; C 115]**
8. Identify the **azygos vein** on the right side of the mediastinum. The **arch of the azygos vein** passes superior to the root of the right lung and drains into the posterior surface of the superior vena cava.
9. Cut the superior vena cava just superior to the entrance of the azygos vein. Reflect the superior vena cava and the brachiocephalic veins superiorly.
10. Identify the **right phrenic nerve** and the **left phrenic nerve** that pass posterior to the brachiocephalic veins. The phrenic nerves were previously dissected in the middle mediastinum. Note that the right and left phrenic nerves pass anterior to the roots of the right and left lungs, respectively. Demonstrate that the phrenic nerves accompany the pericardiacophrenic vessels and that they enter the superior surface of the diaphragm.
11. Identify the **arch of the aorta** (Fig. 3.28). The arch of the aorta begins and ends at the level of the sternal angle. **[G 79; N 227; R 271; C 117]**
12. Identify the three arteries that arise from the arch of the aorta (Fig. 3.28). From anterior to posterior, they are the **brachiocephalic trunk**, the **left common carotid artery**, and the **left subclavian artery**.
13. Identify the **ligamentum arteriosum**. The ligamentum arteriosum is a fibrous cord that connects the concavity of the arch of the aorta to the left pulmonary artery (Fig. 3.28).
14. Identify the **left vagus nerve** and the **left recurrent laryngeal nerve** on the left side of the arch of the aorta (Fig. 3.29). Follow the left vagus nerve inferiorly and note that it passes posterior to the root of the left lung toward the esophagus. Review the relationship of the left recurrent laryngeal nerve to the ligamentum arteriosum.

CLINICAL CORRELATION

Left Recurrent Laryngeal Nerve

The left recurrent laryngeal nerve has a close relationship to the aortic arch and passes through the superior mediastinum. In cases of mediastinal tumors or an aneurysm of the aortic arch, the left recurrent laryngeal nerve may be compromised, resulting in paralysis of the left vocal fold and hoarseness.

15. On the right side, note that the **right vagus nerve** passes posterior to the root of the right lung (Fig. 3.29). The **right recurrent laryngeal nerve** (a branch of the right vagus nerve) loops around the right subclavian artery.

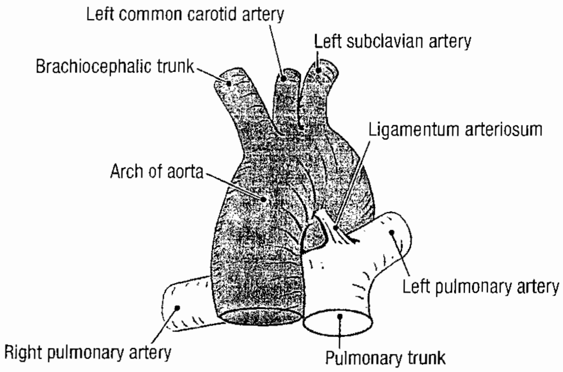


Figure 3.28. Branches of the arch of the aorta.

16. Identify the **trachea**. Observe that **tracheobronchial lymph nodes** are located on both sides of the trachea near its bifurcation.
17. Identify the **bifurcation of the trachea**. The trachea bifurcates at the plane of the sternal angle to form the **right main bronchus** and the **left main bronchus**. Note that the arch of the azygos vein passes superior to the right main bronchus and the arch of the aorta passes superior to the left main bronchus.
18. Palpate the anterior and posterior surfaces of the trachea near its bifurcation. Observe that the **tracheal rings** are "C-shaped" and that the open part of the "C" is located posteriorly.
19. Observe that the esophagus is located posterior to the trachea in close relationship to the open part of the tracheal cartilages.
20. Use scissors to make a longitudinal cut through the anterior surface of the right and left main bronchi. The cuts should meet anterior to the tracheal bifurcation. Make a third cut superiorly through the anterior surface of the trachea for a distance of 2.5 cm. Inside the tracheal bifurcation, identify the **carina** (L. *carina*, keel of a boat). The carina is a specialized piece of tracheal cartilage (Fig. 3.29).
21. Compare the right and left main bronchi. Observe that the right main bronchus is larger in diameter, shorter, and oriented more vertically than the left main bronchus.

CLINICAL CORRELATION

Bifurcation of the Trachea

During bronchoscopy, the carina serves as an important landmark because it lies between the superior ends of the right and left main bronchi. The carina is usually positioned slightly to the left of the median plane of the trachea. When foreign bodies are aspirated, they usually enter the right main bronchus because it is wider and more vertically oriented than the left main bronchus.

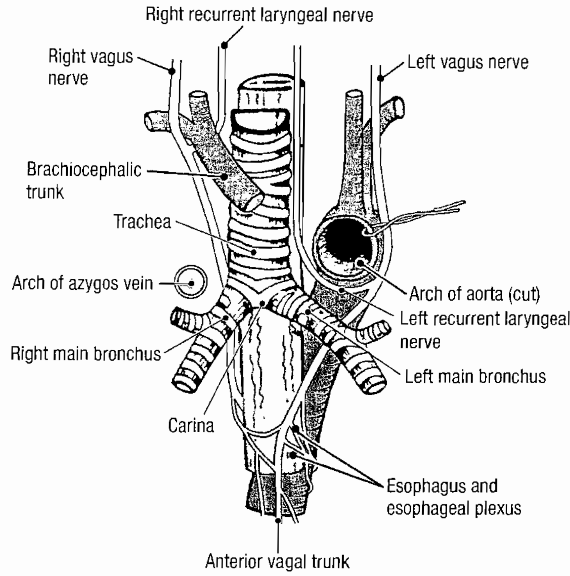


Figure 3.29. Course of the right and left vagus nerves.

After you dissect . . .

Replace the contents of the superior mediastinum into their correct anatomical positions. Return the anterior thoracic wall to its correct anatomical position. Project the structures of the superior mediastinum to the surface of the thoracic wall. Reflect the anterior thoracic wall. Review the formation of the superior vena cava and the position of the arch of the azygos vein. Review the position of the ascending aorta and the position of the arch of the aorta. Review the branches of the arch of the aorta. Compare the relationships of the phrenic and vagus nerves at the root of the lung. Contrast the thoracic course of the left recurrent laryngeal nerve to the thoracic course of the right recurrent laryngeal nerve.

POSTERIOR MEDIASTINUM

Before you dissect . . .

The posterior mediastinum contains structures that course between the thorax and the abdomen. The posterior mediastinum lies posterior to the pericardium. The structures in the posterior mediastinum will be approached through the **posterior wall of the pericardium.**

The order of dissection will be as follows: the pericardium will be reviewed and its posterior wall will be removed. The esophagus will be studied. The azygos vein and its tributaries will be studied. The thoracic duct will be identified. Then, the aorta and its branches will be dissected. Finally, the thoracic portion of the sympathetic trunk and its branches will be dissected.

Dissection Instructions

1. Study the **boundaries of the posterior mediastinum** (Fig. 3.16):
   - **Superior** – plane of the sternal angle
   - **Posterior** – bodies of vertebrae T5 to T12:

- **Anterior** – pericardium
- **Lateral** – mediastinal pleurae (left and right)
- **Inferior** – diaphragm

2. Review the interior of the pericardium (Fig. 3.19).
3. Place the heart back into the pericardium. From the right side of the thorax, examine the relationship of the heart to the esophagus. Note that the esophagus lies immediately posterior to the left atrium and part of the left ventricle. Remove the heart.
4. Remove the posterior wall of the pericardium in the **area of the oblique sinus** (Fig. 3.30). Identify the **esophagus.** The esophagus is a muscular tube that sits just to the right of the midline. To the left and slightly posterior to the esophagus is the **thoracic aorta.**
5. Use blunt dissection to remove the remainder of the posterior wall of the pericardium. Leave the portion adhering to the diaphragm undisturbed. Use scissors to cut the pericardium at its attachments to the great vessels and diaphragm and place the pericardium in the tissue container. **[G 80; N 228; R 264; C 148]**
6. Use blunt dissection to clean the **esophagus.** Note that the surface of the esophagus is covered by the **esophageal plexus of nerves** (Fig. 3.30). The esophageal plexus innervates the inferior portion of the esophagus.
7. Identify the **right vagus nerve** posterior to the root of the right lung (Fig. 3.31). Follow the right vagus nerve inferiorly and verify that its fibers spread out on the surface of the esophagus.
8. Identify the **left vagus nerve** as it crosses the left side of the arch of the aorta. Follow the left vagus nerve posterior to the root of the left lung and confirm that its fibers contribute to the esophageal plexus.

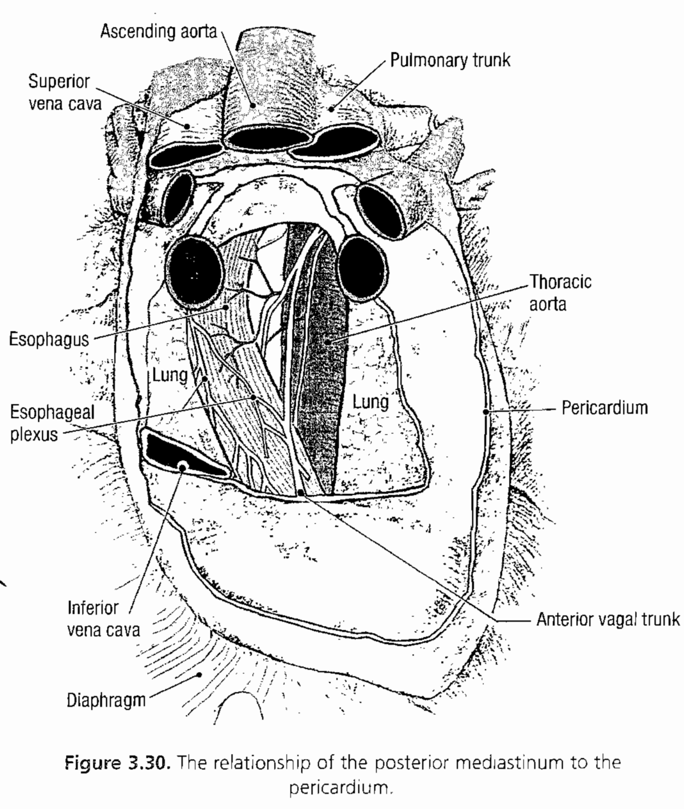


Figure 3.30. The relationship of the posterior mediastinum to the pericardium.

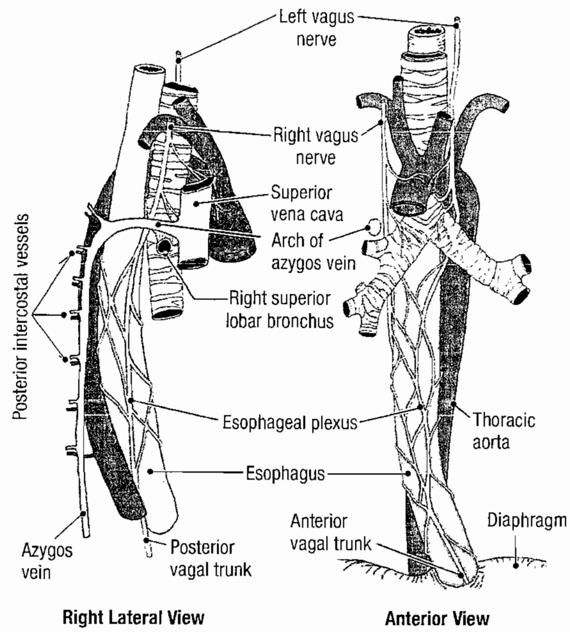


Figure 3.31. Contents of the posterior mediastinum.

9. Identify the **anterior vagal trunk** and the **posterior vagal trunk.** The vagal trunks are found on the inferior part of the esophagus, just before it passes through the diaphragm (Fig. 3.31). The vagal trunks pass through the diaphragm with the esophagus to supply a large part of the gastrointestinal tract.
10. Use an illustration to study the **azygos system of veins. [G 76; N 234; R 269; C 149]**
11. Identify the **azygos vein** where it arches superior to the root of the right lung (Fig. 3.31). Clean the azygos vein and follow it inferiorly to the level of the diaphragm. Note that the **posterior intercostal veins** on the right side are tributaries to the azygos vein. **[G 80; N 234; R 269; C 149]**
12. On the left side of the posterior mediastinum, observe that the left posterior intercostal veins drain into the **hemiazygos vein** and **accessory hemiazygos vein.** Note that variations of the azygos system are common.
13. Identify the **thoracic duct.** To find the thoracic duct, retract the esophagus to the left and explore the interval between the **azygos vein** and the **thoracic aorta.** The thoracic duct lies immediately to the left of the azygos vein and is posterior to the esophagus. The thoracic duct is thin-walled and easily torn. It has the appearance of a small vein without blood in it. **[G 74; N 305; R 267; C 149]**
14. Use a probe to free the thoracic duct from the surrounding connective tissue. The thoracic duct may be a network of several small ducts instead of a single duct. The thoracic duct passes through the diaphragm with the thoracic aorta. Superiorly, the thoracic duct drains into the junction of the left internal jugular vein and left subclavian vein. Do not demonstrate its termination at this time.

15. Note that the thoracic duct crosses the anterior surface of the **right posterior intercostal arteries**, the **hemiazygos vein**, and the **accessory hemiazygos vein**. Demonstrate the veins but preserve the thoracic duct.
16. Identify the **thoracic aorta.** Use a probe to clean it from the surrounding connective tissue.
17. Identify **esophageal arteries** and **bronchial arteries.** Both types of arteries are unpaired vessels that arise from the anterior surface of the aorta. They are distinguished by their area of distribution.
18. Dissect one pair of **posterior intercostal arteries** (right and left). Follow them to the intercostal space. Note that the right posterior intercostal arteries cross the midline on the anterior surface of the vertebral bodies. The right posterior intercostal arteries pass posterior to all other contents of the posterior mediastinum.
19. On both sides, identify and clean one **intercostal nerve.** Follow it laterally until it disappears posterior to the **innermost intercostal muscle.**
20. On both sides of the thorax, identify the **sympathetic trunk.** Starting high in the thorax, follow the sympathetic trunk inferiorly and observe that it crosses the heads of ribs 2 to 9. Inferior to rib 9, observe that the sympathetic trunk lies on the sides of the thoracic vertebral bodies. **[G 80; N 236; R 270; C 152]**
21. Observe that the sympathetic trunk has one **sympathetic ganglion** for each thoracic segment.
22. Demonstrate that two **rami communicantes** (**white ramus communicans, gray ramus communicans**) connect each intercostal nerve with its corresponding thoracic sympathetic ganglion. During dissection, it is impossible to distinguish white and gray rami from each other based on color.
23. Use a probe to dissect the **greater splanchnic nerve** on both the right and left sides. Note that the greater splanchnic nerve receives contributions from the fifth through the ninth thoracic sympathetic ganglia and that it is not completely formed until lower thoracic levels. As an aid to identification, observe that the greater splanchnic nerve is found on the sides of vertebral bodies T5 to T9, whereas the sympathetic trunk crosses the heads of ribs 5 to 9 (i.e., the sympathetic trunk is located more posteriorly).
24. The **lesser splanchnic nerve** arises from the tenth and eleventh thoracic sympathetic ganglia. The **least splanchnic nerve** arises from the twelfth thoracic sympathetic ganglion. Because of the curvature of the diaphragm, these two nerves cannot be seen at this time.

After you dissect . . .

Review the boundaries of the anterior, middle, and posterior mediastina. Study a transverse section through the mid-level of the thorax and identify the contents of the posterior mediastinum. Note the relationship of the contents of the posterior mediastinum to the heart and vertebral bodies. Review the course and function of an intercostal nerve, naming all structures that it innervates. Review the parts of the aorta (ascending, arch, thoracic), naming all branches and describing their distribution. Review the origin and course of the right and left posterior intercostal arteries. Name the structures in the posterior mediastinum that course anterior to the right posterior intercostal arteries.

CHAPTER 4
ABDOMEN

The abdomen is the portion of the trunk that lies between the thorax and the pelvis. The abdominal cavity is divided from the thoracic cavity by the diaphragm but it is continuous with the pelvic cavity. Viscera contained within the abdominal cavity are not bilaterally symmetrical. Therefore, it is worth noting that use of the words "right" and "left" in names and instructions refers to the right and left sides of the cadaver in the anatomical position.

SURFACE ANATOMY

Firm fixation of tissues in the cadaver may make it difficult to distinguish between bony landmarks and well-fixed soft tissue structures. Place the cadaver in the supine position and palpate the following structures (Fig. 4.01): **[N 239]**

- **Xiphoid process**
- **Costal margin**
- **Pubic symphysis**
- **Pubic crest**
- **Pubic tubercle**

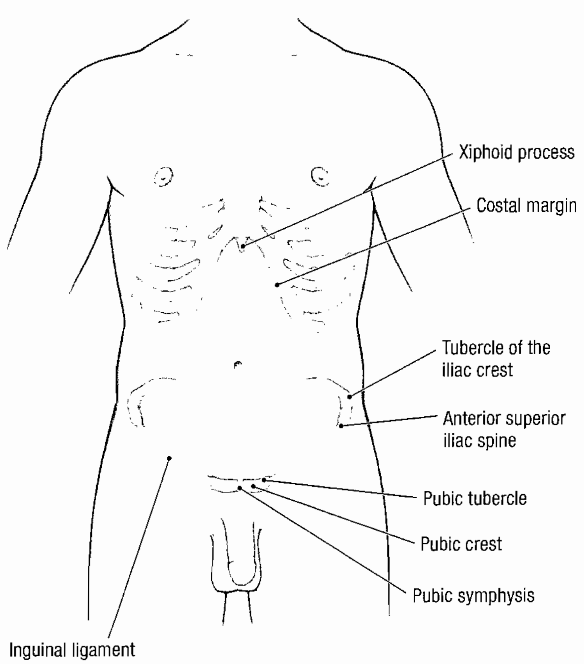


Figure 4.01. Surface anatomy of the abdomen.

KEY TO REFERENCES

G = Grant's Atlas, 11th ed., page number
N = Netter's Atlas, 3rd ed., plate number
R = Rohen's Color Atlas of Anatomy, 5th ed., page number
C = Clemente's Atlas, 4th ed., page number

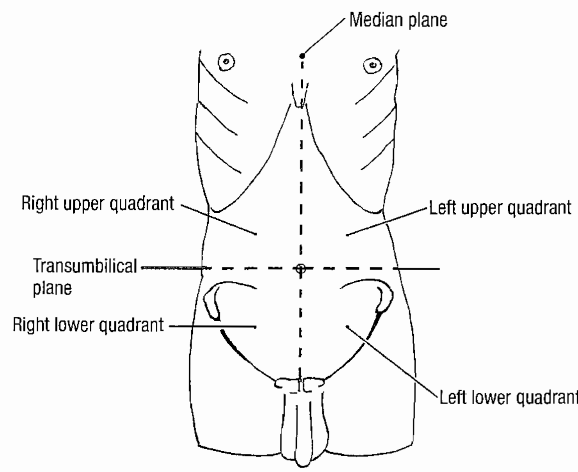


Figure 4.02. The four abdominal quadrants.

- **Inguinal ligament**
- **Anterior superior iliac spine**
- **Tubercle of the iliac crest**

To prepare patient notes, you will need to understand the terminology used to describe the abdomen. The quadrant and regional systems are in common use. The **quadrant system** divides the abdomen by means of the transumbilical plane and the median plane (Fig. 4.02). The quadrant system is suitable for general descriptions and will be used to describe the position of organs in this dissection guide. The **regional system** divides the abdomen based on the right and left midclavicular lines, the subcostal plane and the transtubercular plane (Fig. 4.03). Clinical symptoms may be more specifically described using the regional system.

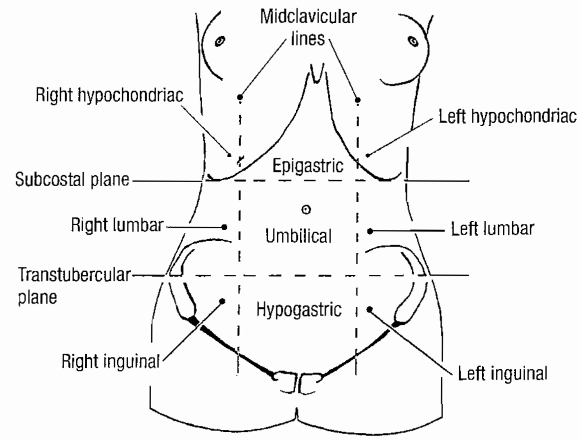


Figure 4.03. The nine abdominal regions

SUPERFICIAL FASCIA OF THE ANTEROLATERAL ABDOMINAL WALL

Before you dissect . . .

The contents of the abdominal cavity are protected by the anterolateral abdominal wall. The organization of the layers forming the anterolateral abdominal wall is illustrated in Figure 4.04. The superficial fascia is unique in this region in that it has a **fatty (superficial) layer** called **Camper's fascia** and a **membranous (deep) layer** called **Scarpa's fascia**. The membranous layer is noteworthy, because it is continuous with named fascias in the perineum. **[G 99; N 244; R 203; C 168]**

Dissection Instructions

SKIN INCISIONS

1. Refer to Figure 4.05.
2. Make a midline skin incision from the xiphisternal junction (C) to the pubic symphysis (E), encircling the umbilicus.
3. Make an incision from the xiphoid process (C) along the costal margin to a point on the midaxillary line (V). If the thorax has been dissected previously, this incision has been made.
4. Make a transverse skin incision from the umbilicus to the midaxillary line.
5. Make a skin incision beginning 2 cm below the pubic crest (E). Extend this incision laterally, 2 cm inferior to the inguinal ligament to a point 2 cm below the anterior superior iliac spine. Continue the incision posteriorly, 2 cm below the iliac crest to a point on the midaxillary line (F).
6. Make a vertical skin incision along the midaxillary line from point "V" to point "F."
7. Reflect the skin from medial to lateral, detach it along the midaxillary line, and place it in the tissue container.

SUPERFICIAL FASCIA

1. Use a probe to tear through the superficial fascia approximately 7.5 cm lateral to the midline (Fig. 4.06).

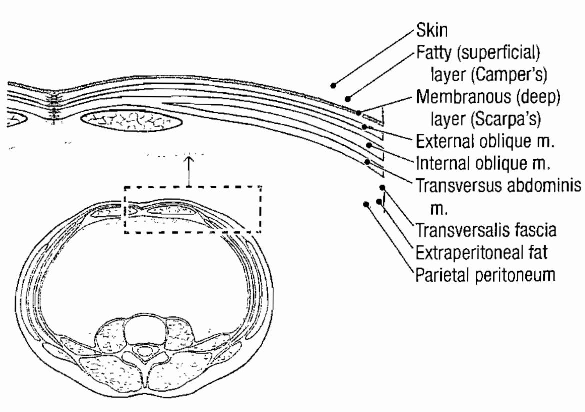


Figure 4.04. Layers of the anterior abdominal wall.

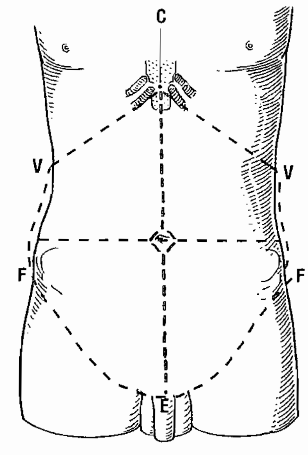


Figure 4.05. Skin incisions.

The **superficial epigastric artery and vein** are in the superficial fascia in this area, but do not make a special effort to find them.

2. Dissect through the superficial fascia down to the aponeurosis of the external oblique muscle. On the medial side of the incision, use your fingers to separate the superficial fascia from the aponeurosis of the external oblique muscle (Fig. 4.06, arrow 1).

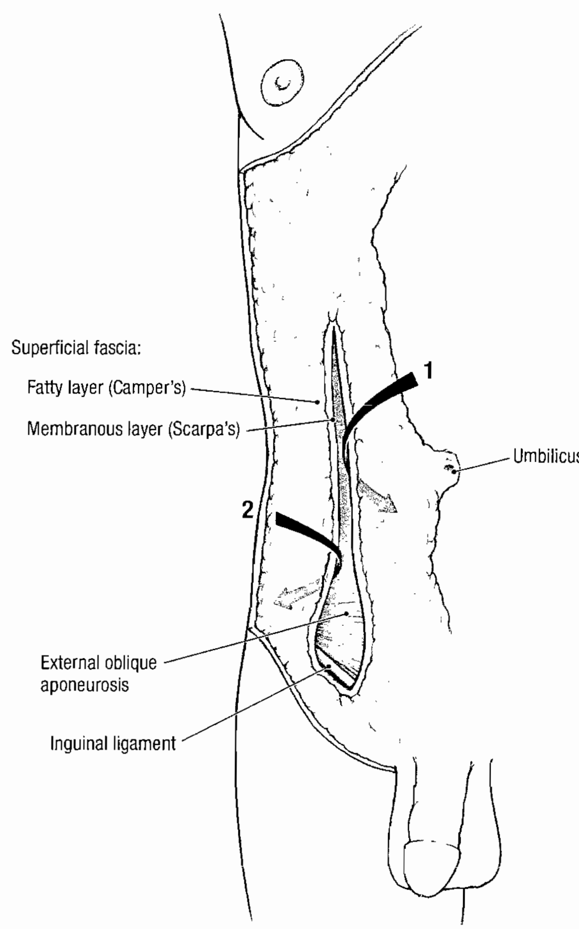


Figure 4.06. Removal of the abdominal superficial fascia.

3. As you approach the midline, palpate the **anterior cutaneous nerves** that enter the superficial fascia approximately 2 to 3 cm lateral to the midline. Clean one anterior cutaneous nerve. Anterior cutaneous nerves are branches of the **thoracoabdominal nerves (T7–T11), the subcostal nerve (T12), and the iliohypogastric and ilioinguinal nerves (L1)**. Consult a dermatome chart and note that: **[G 331; N 157; C 159]**
   - T7 innervates the skin overlying the xiphoid process.
   - T10 innervates the skin of the umbilicus.
   - T12 innervates the skin superior to the pubic symphysis.
   - L1 innervates the skin overlying the pubic symphysis. **[G 97; N 249; R 204; C 161]**
4. Lateral to the incision, use your fingers to separate the superficial fascia from the external oblique muscle (Fig. 4.06, arrow 2). As you near the midaxillary line, palpate the **lateral cutaneous nerves** entering the superficial fascia. The lateral cutaneous nerves are branches of thoracoabdominal nerves. Clean the branches of one lateral cutaneous nerve.
5. Remove the superficial fascia in an inferior direction until the lower border of the external oblique muscle is exposed (approximately 2.5 cm into the proximal thigh).
6. Detach the superficial fascia from the midline, midaxillary line, and proximal thigh and place it in the tissue container.

After you dissect . . .

Use an illustration to review the distribution of the superficial epigastric vessels. Review the abdominal distribution of the ventral primary rami of spinal nerves T7 to L1.

CLINICAL CORRELATION

Superficial Veins of the Abdominal Wall

The superficial epigastric vein anastomoses with the lateral thoracic vein in the superficial fascia. This is an important collateral venous channel from the femoral vein to the axillary vein. In patients who have an obstruction of the inferior vena cava or hepatic portal vein, the superficial veins of the abdominal wall are engorged and become visible around the umbilicus (**caput medusae**).

MUSCLES OF THE ANTEROLATERAL ABDOMINAL WALL

Before you dissect . . .

Three flat muscles (external oblique, internal oblique, and transversus abdominis) form most of the anterolateral abdominal wall. The rectus abdominis muscle completes the anterior abdominal wall near the midline. The three flat muscles have fleshy proximal attachments (to the ribs, vertebrae, and the pelvis) and broad, aponeurotic distal attachments (to the ribs, linea alba, and pubis). Each of the three flat muscles contributes to the formation of the rectus sheath and the inguinal canal.

In the male, the testes are housed in the scrotum, which is an outpouching of the anterior abdominal wall. Each testis passes through the abdominal wall during development, dragging its ductus deferens behind it. This passage occurs through the **inguinal canal.** The inguinal canal is located superior to the medial half of the inguinal ligament and extends from the **superficial (external) inguinal ring** to the **deep (internal) inguinal ring**. In the female, the inguinal canal is smaller in diameter.

It must be noted that the structures forming the inguinal canal are identical in the two sexes, but the *contents* of the inguinal canal differ. In the male, the inguinal canal contains the **spermatic cord**, whereas in the female the inguinal canal contains the **round ligament of the uterus.** Dissection instructions are provided for male cadavers, but these instructions are applicable to female cadavers

The order of dissection will be as follows. The three flat muscles of the abdominal wall will be studied, particularly in the inguinal region. The composition and contents of the rectus sheath will be explored. The anterior abdominal wall will be reflected.

SKELETON OF THE ABDOMINAL WALL

Use a skeleton to identify the following structures (Fig. 4.07): **[G 10, 185; N 240; R 185; C 95, 253]**

- **Xiphisternal junction**
- **Xiphoid process**
- **Costal margin**
- **Pubic symphysis**
- **Pubic crest**
- **Pubic tubercle**
- **Anterior superior iliac spine**
- **Iliac crest**
- **Tubercle of the iliac crest**

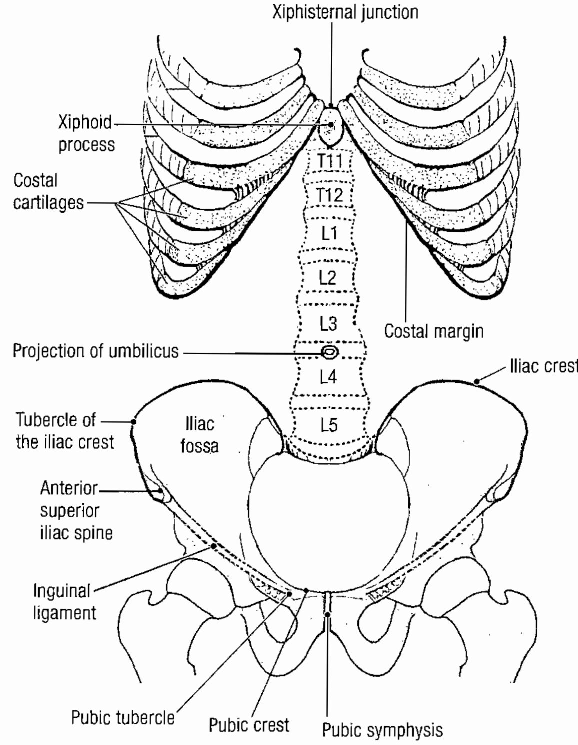


Figure 4.07. Skeleton of the anterior abdominal wall.

Dissection Instructions

EXTERNAL OBLIQUE MUSCLE [G 97; N 241; R 200; C 162]

The external oblique muscle forms the most superficial layer (first arch) of the inguinal canal (Fig. 4.08A, B).

1. Observe the **external oblique muscle**. The proximal attachments of the external oblique muscle are the external surfaces of ribs 5 to 12. The distal attachments of the external oblique muscle are the linea alba, pubic tubercle, and anterior half of the iliac crest. Observe that the fibers of the external oblique muscle course from superolateral to inferomedial.

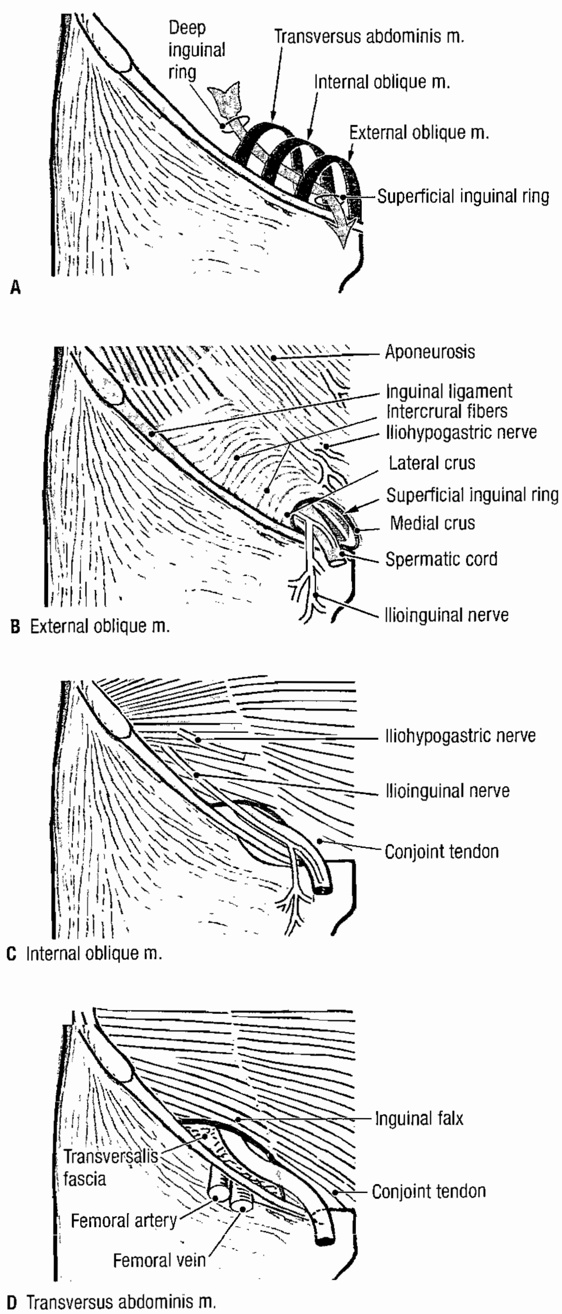


Figure 4.08. Contributions of the flat abdominal muscles to the inguinal canal.

2. In the inguinal region, use blunt dissection to clean the aponeurosis of the external oblique muscle. Gentle scraping motions with a dull scalpel blade yield good results. Be careful not to damage the **spermatic cord** (or **round ligament of the uterus**) where it emerges from the superficial inguinal ring. [G 100, 104; N 241; R 207, 210; C 163]
3. Identify the **superficial inguinal ring** (Fig. 4.08B), which is an opening in the external oblique aponeurosis.
4. Identify the **lateral (inferior) crus**. The lateral crus is the portion of the external oblique aponeurosis that forms the lateral margin of the superficial inguinal ring.
5. Identify the **medial (superior) crus**. The medial crus is the portion of the external oblique aponeurosis that forms the medial margin of the superficial inguinal ring.
6. Identify the **intercrural fibers**. Intercrural fibers span across the crura superolateral to the superficial inguinal ring. They prevent the crura from spreading apart.
7. Note that the **ilioinguinal nerve** emerges from the inguinal canal at the superficial inguinal ring, anterior to the spermatic cord (or round ligament of the uterus). The ilioinguinal nerve supplies sensory fibers to the skin of the external genitalia and the medial aspect of the thigh.
8. Identify the **inguinal ligament**. It is the inferior border of the aponeurosis of the external oblique muscle. Palpate the attachments of the inguinal ligament to the anterior superior iliac spine and to the pubic tubercle. Vessels and nerves exit the abdominal cavity and enter the lower limb by passing deep to the inguinal ligament.

INTERNAL OBLIQUE MUSCLE [G 98; N 242; R 202; C 164]

The internal oblique muscle lies deep to the external oblique muscle. The internal oblique muscle forms the intermediate layer (second arch) of the inguinal canal (Fig. 4.08A, C). To expose the internal oblique muscle, the external oblique muscle must be transected and reflected (Fig. 4.09). Perform this transection bilaterally.

1. In the midaxillary line at the level of the umbilicus, insert closed scissors between the fibers of the external oblique muscle. Open the scissors parallel to the fiber direction to split the external oblique muscle (Fig. 4.09A, cut 1). Make an opening that extends inferiorly as far as the anterior superior iliac spine.
2. Insert your fingers into cut 1 and use blunt dissection to separate the fibers of the external oblique muscle from the underlying internal oblique muscle.
3. Direct your fingers medially in the transumbilical plane and create a tunnel between the external oblique and internal oblique muscles. Note that your fingers cannot pass medial to the semilunar line because the external oblique aponeurosis is fused to the internal oblique aponeurosis.

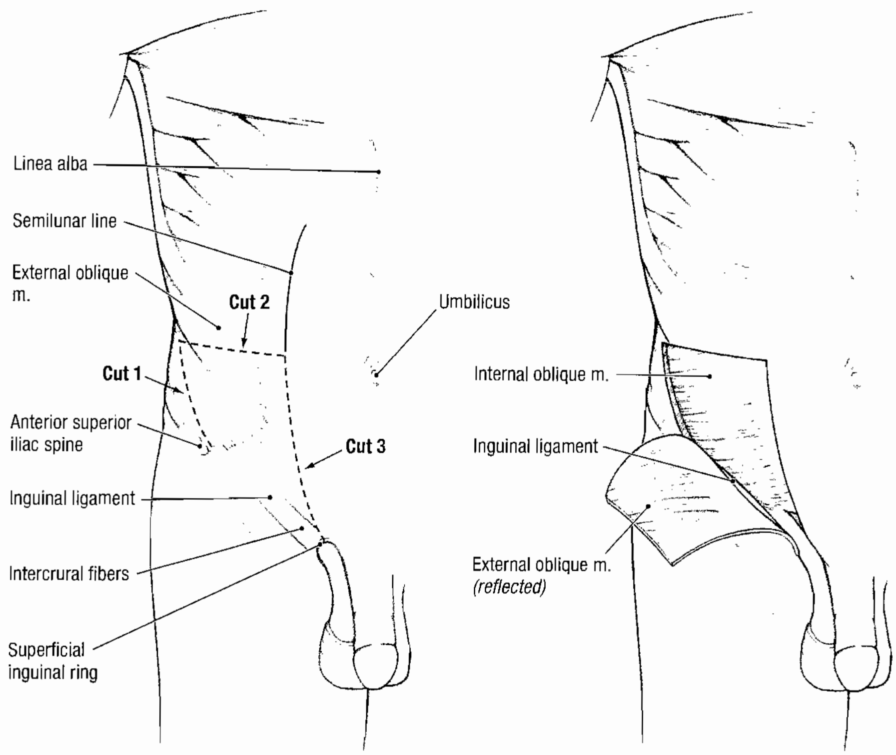


Figure 4.09. Cuts used to reflect the external oblique muscle.

4. Use scissors to cut the external oblique muscle in the transumbilical plane. Extend the cut as far medially as the semilunar line (Fig. 4.09A, cut 2).
5. Inferior to cut 2, use your fingers to separate the external oblique muscle from the internal oblique muscle. Be gentle as you approach the superficial inguinal ring.
6. Using scissors, make an incision from the medial end of cut 2 to the superior margin of the superficial inguinal ring (Fig. 4.09A, cut 3). Cut 3 should follow the lateral side of the semilunar line and cut only the external oblique aponeurosis.
7. Reflect the external oblique muscle in an inferior and lateral direction to reveal the lower half of the internal oblique muscle (Fig. 4.09B).
8. Identify the **internal oblique muscle**. The proximal attachments of the internal oblique muscle are the thoracolumbar fascia, the iliac crest, and the lateral half of the inguinal ligament. The distal attachments of the internal oblique muscle are the inferior border of ribs 10 to 12, the linea alba, the pubic crest, and the pecten pubis.
9. Observe the portion of the internal oblique muscle that arises from the lateral part of the inguinal ligament (Fig. 4.10). Note that this portion of the muscle arches medially to its distal attachment on the pecten pubis and contributes to the roof of the inguinal canal. **[G 101, 105; N 242; R 207, 210; C 165]**
10. Lateral to the spermatic cord (or round ligament of the uterus), observe muscle fibers connecting the internal oblique muscle with the spermatic cord (Fig. 4.10). This is the layer of **cremaster muscle and fas-**

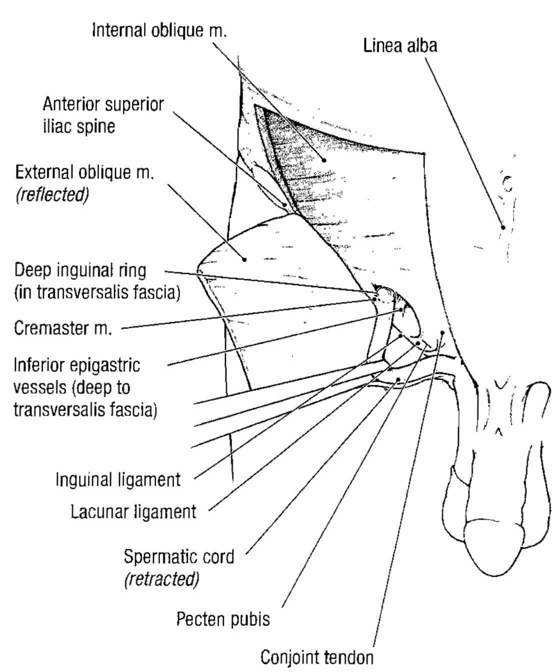


Figure 4.10. The internal oblique muscle in the inguinal region.

cia, which is the contribution of the internal oblique muscle to the coverings of the spermatic cord. In the female, the cremaster muscle and fascia surround the round ligament of the uterus.

11. Once again, find the **ilioinguinal nerve**, which courses through the inguinal canal to emerge at the superficial inguinal ring (Fig. 4.08C). Also, identify the **iliohypogastric nerve**, which runs parallel and superior to the ilioinguinal nerve.
12. Just medial to the superficial inguinal ring the aponeurosis of the internal oblique becomes fused with the aponeurosis of the transversus abdominis muscle to form the **conjoint tendon** (Fig. 4.08C).

TRANSVERSUS ABDOMINIS MUSCLE [G 98; N 243; R 205; C 167]

The **transversus abdominis muscle** lies deep to the internal oblique muscle. The transversus abdominis muscle forms the deepest layer (third arch) of the inguinal canal (Fig. 4.08A, D). In the inguinal region, the transversus abdominis muscle has attachments and fiber directions that are similar to the internal oblique muscle.

1. Use an illustration to study the proximal attachments, distal attachments, and fiber direction of the transversus abdominis muscle. The proximal attachments of the transversus abdominis muscle are the internal surfaces of the costal cartilages of ribs 7 to 12, the thoracolumbar fascia, the iliac crest, and the lateral third of the inguinal ligament. The distal attachments of the transversus abdominis muscle are the linea alba, the pubic crest, and the pecten pubis. **[G 102; N 243; R 208; C 181]**

Dissection note: The transversus abdominis muscle is often difficult to separate from the internal oblique muscle because their tendons are fused near their distal attachments (conjoint tendon), and the muscle bellies adhere to each other laterally. If you are not required to separate the internal oblique muscle from the transversus abdominis muscle, go to the section entitled "Deep Inguinal Ring." If you are required to separate the internal oblique muscle from the transversus abdominis muscle, proceed with the next dissection step.

2. Use a probe to follow the ilioinguinal nerve superolaterally until it enters the internal oblique muscle (Fig. 4.08C).
3. Insert a pair of closed scissors into the internal oblique muscle superficial to the course of the ilioinguinal nerve and open the scissors parallel to the fiber direction to split the muscle. Follow the ilioinguinal nerve proximally and use it as a guide to find the plane between the internal oblique and transversus abdominis muscles.
4. Insert your finger through the split and into the plane between the internal oblique and transversus abdominis muscles. Push your finger inferiorly and medially to separate the muscles. Proceed until you reach the inferior borders of the two muscles. Observe that the aponeuroses of the two muscles are inseparable near their attachment to the pecten pubis (conjoint tendon).
5. Note that the inferior free edge of the transversus abdominis muscle is slightly superior to the inferior free edge of the internal oblique muscle. Below the arch formed by these two muscles, the abdominal wall is unsupported by muscle. This weak point occurs directly posterior to the superficial inguinal ring.

DEEP INGUINAL RING [G 103; N 251; R 208; C 181]

Transversalis fascia lines the inner surface of the abdominal muscles (Fig. 4.04). The **deep inguinal ring** is the point at which the testis passed through the transversalis fascia during development. The deep inguinal ring is located superior to the midpoint of the inguinal ligament and it marks the deep extent of the inguinal canal. In the male, the ductus deferens passes through the deep inguinal ring. In the female, the round ligament of the uterus passes through the deep inguinal ring.

1. Use a probe to lift the inferior margin of the fused internal oblique and transversus abdominis muscles.
2. Use blunt dissection to separate the transversus abdominis muscle from the transversalis fascia.
3. Retract the spermatic cord (or round ligament of the uterus) laterally and observe the **inferior epigastric vessels** through the transversalis fascia (Fig. 4.10). The inferior epigastric vessels are located within the layer of extraperitoneal (endoabdominal) fat.
4. The location of the deep inguinal ring is lateral to the inferior epigastric vessels and is identified by the presence of the ductus deferens (or round ligament of the uterus).
5. To review, the **boundaries of the inguinal canal** are (Fig. 4.08):
   - **Deep** – deep inguinal ring
   - **Superficial** – superficial inguinal ring
   - **Anterior** – aponeurosis of the external oblique muscle
   - **Inferior** (floor) – inguinal ligament
   - **Superior** (roof) – the arching fibers of the internal oblique and the transversus abdominis muscles
   - **Posterior** – transversalis fascia, reinforced medially by the conjoint tendon

CLINICAL CORRELATION

Inguinal Hernias

The inguinal canal is a weak area of the abdominal wall through which abdominal viscera may protrude (inguinal hernia). The identifying characteristic of an inguinal hernia is its position relative to the inferior epigastric vessels. An **indirect inguinal hernia** exits the abdominal cavity through the deep inguinal ring *lateral* to the inferior epigastric vessels, and it follows the inguinal canal (an indirect course through the abdominal wall) (Fig. 4.11B). In contrast, a **direct inguinal hernia** exits the abdominal cavity *medial* to the inferior epigastric vessels and takes a direct course through the abdominal wall (Fig. 4.11C).

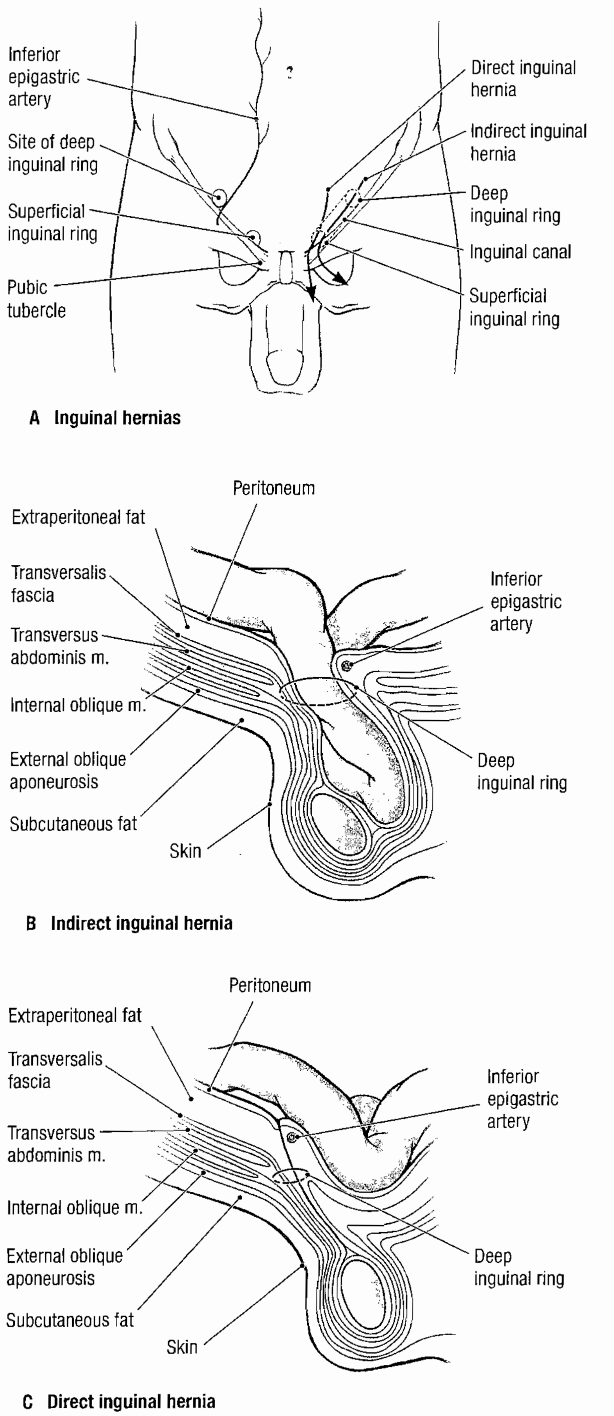


Figure 4.11. Inguinal hernias. **A.** Anatomical relationships and course through the abdominal wall. **B.** An indirect inguinal hernia leaves the abdominal cavity lateral to the inferior epigastric vessels and passes down the inguinal canal. **C.** A direct inguinal hernia leaves the abdominal cavity medial to the inferior epigastric vessels.

RECTUS ABDOMINIS MUSCLE [G 97; N 242; R 201; C 167]

The **rectus sheath** is formed by the aponeuroses of the three flat abdominal muscles. The rectus sheath contains the **rectus abdominis muscle**, the **superior** and **inferior epigastric vessels**, the terminal ends of the ventral primary rami of spinal nerves T7 to T12, and the **pyramidalis muscle**.

1. Reposition the internal oblique and external oblique muscles. The following cuts should be made bilaterally.
2. Use scissors to make a transverse incision across the anterior surface of the rectus sheath at the level of the umbilicus (Fig. 4.12, cut 1). Begin the cut approximately 2.5 cm lateral to the umbilicus and continue laterally as far as the semilunar line.
3. Use scissors to cut the rectus sheath along the medial border of the **rectus abdominis muscle** (Fig. 4.12, cut 2). This incision should extend in a superior direction, approximately 2.5 cm from the midline. Stop at the costal margin.
4. Extend the vertical incision inferiorly along the medial border of the rectus abdominis muscle (Fig. 4.12, cut 3). Cut 3 should be approximately 1.2 cm from the midline and stop at the pubic crest.
5. Insert your fingers into the vertical incision and bluntly dissect the anterior wall of the rectus sheath from the anterior surface of the rectus abdominis muscle. Observe that the anterior wall of the rectus sheath is firmly attached to the anterior surface of the rectus muscle by several **tendinous intersections** (Fig. 4.13). Use scissors to cut the tendinous intersections and free the rectus sheath from the rectus abdominis muscle.
6. Observe the **rectus abdominis muscle** (Fig. 4.13). The inferior attachment of the rectus abdominis muscle is the symphysis and body of the pubis. The superior attachment of the rectus abdominis muscle is onto the costal cartilages of ribs 5 to 7. The rectus abdominis muscle flexes the trunk.

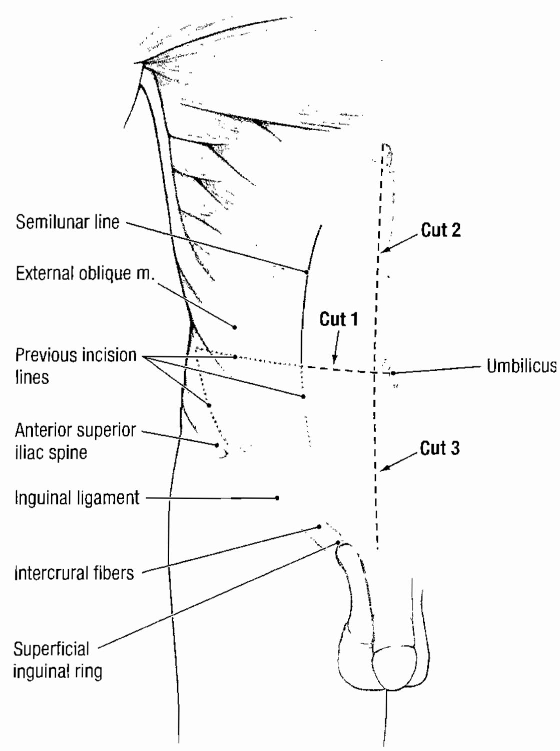


Figure 4.12. Cuts used to open the rectus sheath.

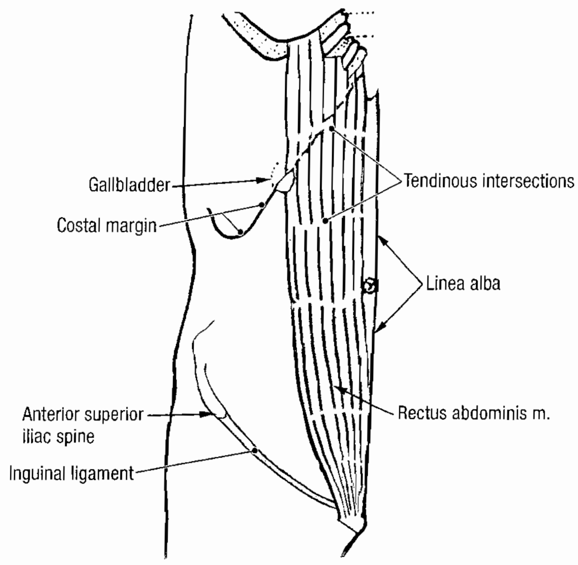


Figure 4.13. Rectus abdominis muscle.

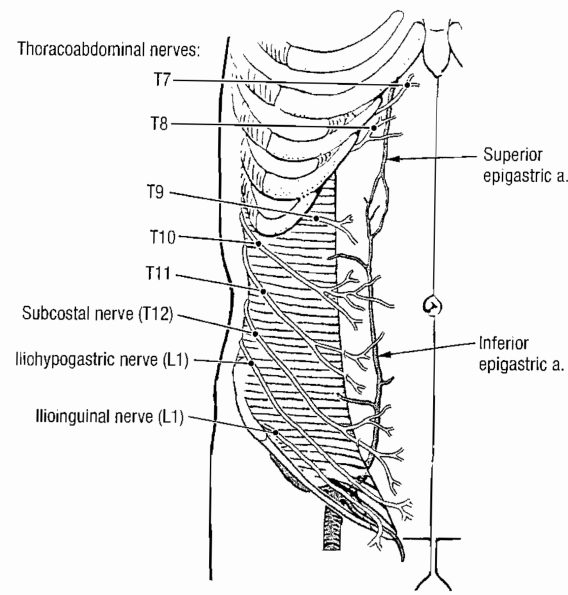


Figure 4.14. Nerves and arteries within the rectus sheath. The rectus abdominis muscle has been removed.

7. Observe that the branches of six thoracoabdominal nerves (T7–T12) enter the lateral side of the rectus sheath (Fig. 4.14). These nerves innervate the rectus abdominis muscle then continue toward the midline as **anterior cutaneous nerves. [G 98; N 249; R 206; C 170]**
8. Use your fingers to mobilize the medial border of the rectus abdominis muscle. At the level of the umbilicus, transect the rectus abdominis muscle with scissors. Reflect the two halves superiorly and inferiorly, respectively. If the thoracoabdominal nerves prevent full reflection of the rectus abdominis muscle, cut them along the lateral border of the muscle.
9. Observe the **superior epigastric artery and vein** on the posterior (deep) surface of the superior half of the rectus abdominis muscle. **[G 98; N 247; R 206; C 170]**
10. Observe the **inferior epigastric artery and vein** on the posterior surface of the inferior half of the rectus abdominis muscle.

CLINICAL CORRELATION

Epigastric Anastomoses

The superior epigastric vessels anastomose with the inferior epigastric vessels within the rectus sheath (Fig. 4.14). If the inferior vena cava becomes obstructed, the anastomosis between the inferior epigastric and superior epigastric veins provides a collateral venous channel that drains into the superior vena cava. If the aorta is occluded, collateral arterial circulation to the lower part of the body occurs through the superior and inferior epigastric arteries.

11. Examine the posterior wall of the rectus sheath (Fig. 4.15). Identify the **arcuate line,** which is located midway between the pubic symphysis and the umbilicus. The arcuate line is the inferior limit of the posterior wall of the rectus sheath, and it may be indistinct. At the level of the arcuate line, the inferior epigastric vessels enter the rectus sheath.
12. Inferior to the arcuate line, observe the **transversalis fascia** and, deep to it, the **parietal peritoneum** (Fig. 4.15).
13. In the midline, observe the **linea alba.** The linea alba is formed by the fusion of the aponeuroses of the right and left flat abdominal muscles (external oblique, internal oblique, and transversus abdominis).
14. Anterior to the inferior end of the rectus abdominis muscle, look for the **pyramidalis muscle.** It is frequently absent. When present, the pyramidalis muscle attaches to the anterior surface of the pubis and the linea alba and it draws down on the linea alba.

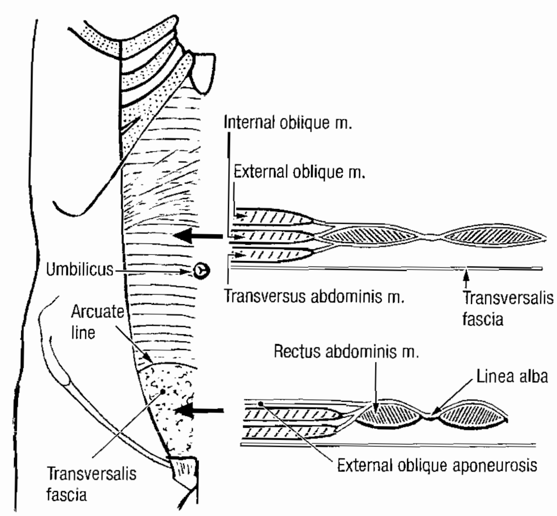


Figure 4.15. Posterior wall of the rectus sheath (left) and transverse sections of the rectus sheath at the two levels indicated by the arrows.

After you dissect . . .

Replace the muscles of the anterior abdominal wall in their correct anatomical positions. Review the proximal attachment, distal attachment, and action of each muscle. Review the structures that form the nine layers of the abdominal wall (Fig. 4.04). Use the dissected specimen to review the rectus sheath at the level of the umbilicus and just superior to the pubic symphysis (Fig. 4.15). Review the nerve supply to the anterior abdominal wall. Review the blood supply to the anterior abdominal wall.

LABIUM MAJUS IN THE FEMALE; SCROTUM, SPERMATIC CORD, AND TESTIS IN THE MALE

Before you dissect . . .

The **scrotum** is an outpouching of the anterior abdominal wall, and most layers of the abdominal wall are represented in its structure (Fig. 4.16). The superficial fascia of the scrotum contains no fat. Instead, the superficial fascia is represented by **dartos fascia**, which contains smooth muscle fibers (**dartos muscle**).

The order of dissection will be as follows. The scrotum (labium majus) will be opened by an anterior incision. The spermatic cord (round ligament of the uterus in the female) will be followed into the scrotum (labium majus in the female). The testis will be removed from the scrotum. The spermatic cord will be dissected. The testis will be studied.

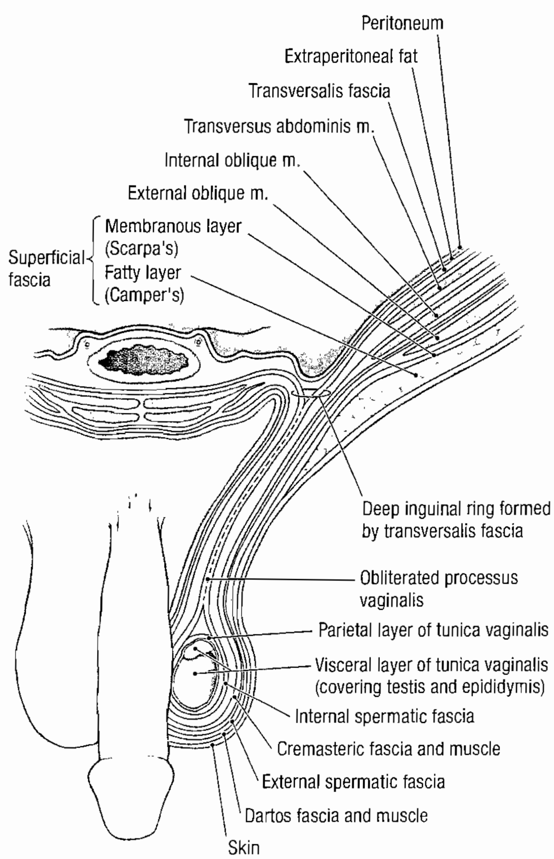


Figure 4.16. Contributions of the anterior abdominal wall to the coverings of the spermatic cord and testis.

Dissection Instructions

MALE AND FEMALE CADAVERS [G 104; R 210; C 176]

1. Partner with a dissection team that has a cadaver of the opposite sex for the following dissection.
2. Inferior to the superficial inguinal ring, insert your finger deep to the subcutaneous tissue of the lower anterior abdominal wall and push your finger into the scrotum. If you are dissecting a female cadaver, your finger will pass into the labium majus.
3. Use scissors to make an incision down the anterior surface of the scrotum (labium) through the skin, dartos, and superficial fascia.
4. Use your fingers to free the testis and spermatic cord from the scrotum. In the female cadaver, demonstrate that the round ligament of the uterus ends in the fatty tissue of the labium majus. This step completes the dissection of the female anatomy.

MALE CADAVER [G 107; N 370; R 329; C 182]

1. Observe a band of tissue that anchors the inferior pole of the testis to the scrotum. This is the **scrotal ligament** (the remnant of the gubernaculum testis).
2. Use scissors to cut the scrotal ligament. Use your fingers to remove the testis from the scrotum, but leave the testis attached to the spermatic cord.
3. Observe that the **scrotal septum** divides the scrotum into two compartments.

Spermatic Cord [G 108; N 370; R 329; C 182]

The spermatic cord contains the ductus deferens, testicular vessels, lymphatics, and nerves. The contents of the spermatic cord are surrounded by three fascial layers, the **coverings of the spermatic cord**, that are derived from layers of the anterior abdominal wall (Fig. 4.16). These coverings are added to the spermatic cord as it passes through the inguinal canal.

1. Study an illustration of a transverse section through the spermatic cord (Fig. 4.17).
2. Palpate the **ductus deferens (vas deferens)** within the spermatic cord. It is hard and cord-like.
3. Use a probe to longitudinally incise the **coverings of the spermatic cord.** The three coverings are fixed to each other at the time of embalming and cannot be

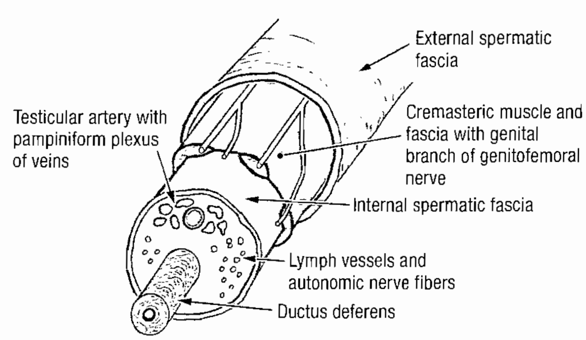


Figure 4.17. Transverse section through the spermatic cord

separated. The coverings of the spermatic cord are (Fig. 4.16):

- **External spermatic fascia** – derived from the external oblique muscle
- **Cremasteric muscle and fascia** – derived from the internal oblique muscle
- **Internal spermatic fascia** – derived from the transversalis fascia

4. Use a probe to separate the ductus deferens from the **pampiniform plexus of veins**.
5. Follow the ductus deferens superiorly into the inguinal canal and toward the deep inguinal ring. Note that the ductus deferens passes through the deep inguinal ring lateral to the inferior epigastric vessels.
6. Use a probe to separate the **testicular artery** from the pampiniform plexus of veins. The testicular artery can be distinguished from the veins by its slightly thicker wall.
7. Note that sensory nerve fibers, autonomic nerve fibers, and lymphatic vessels accompany the blood vessels in the spermatic cord (Fig. 4.17), but they are too small to dissect.

CLINICAL CORRELATION

Vasectomy

The ductus deferens can be surgically interrupted in the superior part of the scrotum (vasectomy). As a precaution against reconnection, a small segment is removed. Sperm production in the testes continues but the spermatozoa cannot reach the urethra.

Testis [G 110; N 371; R 329; C 183, 184]

1. The testis is covered by the **tunica vaginalis**, a serous sac that is derived from the parietal peritoneum (Fig. 4.16). The tunica vaginalis has a visceral layer and a parietal layer (Fig. 4.18).
2. Use scissors to incise the parietal layer of the tunica vaginalis along its anterior surface and open it widely. Observe that the visceral layer of the tunica vaginalis covers the anterior, medial, and lateral surfaces of the testis, but not its posterior surface.
3. Use a probe to trace the ductus deferens inferiorly until it joins the epididymis. Identify the **tail**, **body**, and **head of the epididymis** (Fig. 4.18).
4. Use a scalpel to section the testis longitudinally from its superior pole to its inferior pole. Make the cut along its anterior surface. Use the epididymis as a hinge, and open the halves of the testis like a book.
5. Note the thickness of the **tunica albuginea**, which is the fibrous capsule of the testis. Observe the **septa** that divide the interior of the testis into **lobules** (Fig. 4.18).
6. Use a needle forceps to tease some of the **seminiferous tubules** out of one lobule.

CLINICAL CORRELATION

Lymphatic Drainage of the Testis

Lymphatics from the scrotum drain to the superficial inguinal lymph nodes. Inflammation of the scrotum may cause tender, enlarged superficial inguinal lymph nodes. In contrast, lymphatics from the testis follow the testicular vessels through the inguinal canal and into the abdominal cavity where they drain into lumbar (lateral aortic) nodes and preaortic lymph nodes. Testicular tumors may metastasize to lumbar and preaortic lymph nodes, not to superficial inguinal lymph nodes.

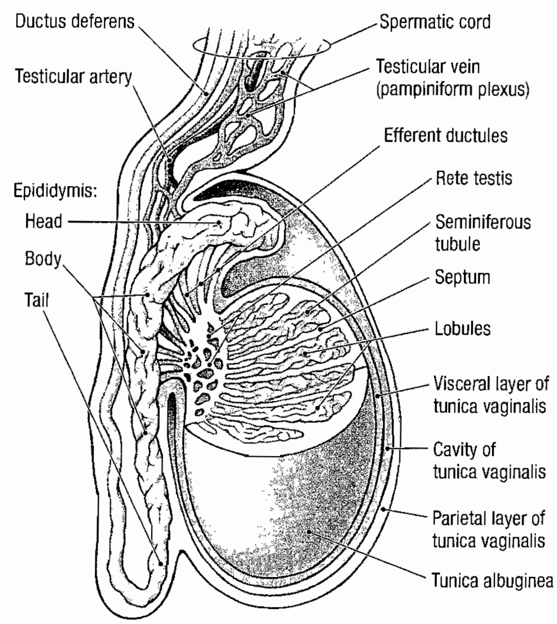


Figure 4.18. Parts of the testis and epididymis.

After you dissect . . .

Review the course of the ductus deferens from the abdominal wall to the testis. Review the coverings of the spermatic cord and recall the layers of the abdominal wall from which they are derived. Use an illustration to trace the route of spermatozoa from their origin in the seminiferous tubule to the ejaculatory duct.

REFLECTION OF THE ABDOMINAL WALL

Before you dissect . . .

The anterior abdominal wall will be reflected in such a way that the contents of the abdominopelvic cavity can be accessed, but the abdominal wall can be repositioned for review. The incision lines will be similar to the quadrant lines illustrated in Figure 4.02. The incisions are designed to give direct reference to the position of the abdominal organs within the abdominal quadrants.

The order of dissection is as follows. The anterior abdominal wall will be incised and opened. The inner surface of the anterior abdominal wall will be studied.

Dissection Instructions

1. Reflect the halves of the rectus abdominis muscles superiorly and inferiorly.
2. Refer to Figure 4.19. On the left side of the umbilicus, use scissors to create a small hole (2 cm) through the posterior wall of the rectus sheath, extraperitoneal fat, and parietal peritoneum.
3. Insert your finger through the hole into the abdominal cavity. Pull the posterior wall of the rectus sheath anteriorly to create a space between the abdominal wall and the abdominal viscera.
4. Use scissors to make a vertical incision through the linea alba to the xiphoid process (Fig. 4.19, cut 1). Stay 1 cm to the left of the midline to preserve the falciform ligament.
5. Extend the incision inferiorly as far as the pubic symphysis (Fig. 4.19, cut 2). Stay 1 cm to the left of the midline to preserve the median umbilical fold.
6. Return the rectus abdominis muscle and the external oblique muscle to their correct anatomical positions.
7. At the level of the umbilicus, place one hand through the vertical incision and raise the abdominal wall from the abdominal contents.
8. On the right side, use scissors to incise the posterior wall of the rectus sheath, extraperitoneal fat, and peritoneum in the transumbilical plane (Fig. 4.19, cut 3). The scissors should pass through the previous transverse cut that was made in the rectus abdominis muscle and the external oblique muscle. Extend the cut through all three flat abdominal muscles as far laterally as the midaxillary line. Duplicate the transverse cut on the left side.
9. Open the flaps of the abdominal wall.
10. Identify the **falciform ligament**, which is superior to the umbilicus. It is attached to the right upper quadrant flap. The falciform ligament connects the anterior abdominal wall to the surface of the liver. **[G 112; N 245; R 283; C 173]**
11. Identify the **median umbilical fold**, which is inferior to the umbilicus. It is attached to the right lower quadrant flap, but may have been cut longitudinally. The median umbilical fold contains the urachus (obliterated allantoic duct).
12. Identify the **medial umbilical fold**. There are two medial umbilical folds, one on each side of the median umbilical fold. The medial umbilical fold contains the obliterated umbilical artery.
13. Find a **lateral umbilical fold** just lateral to each medial umbilical fold. The lateral umbilical fold overlies the inferior epigastric artery and vein.
14. Lateral to the lateral umbilical fold, observe a small depression that marks the location of the **deep inguinal ring**.

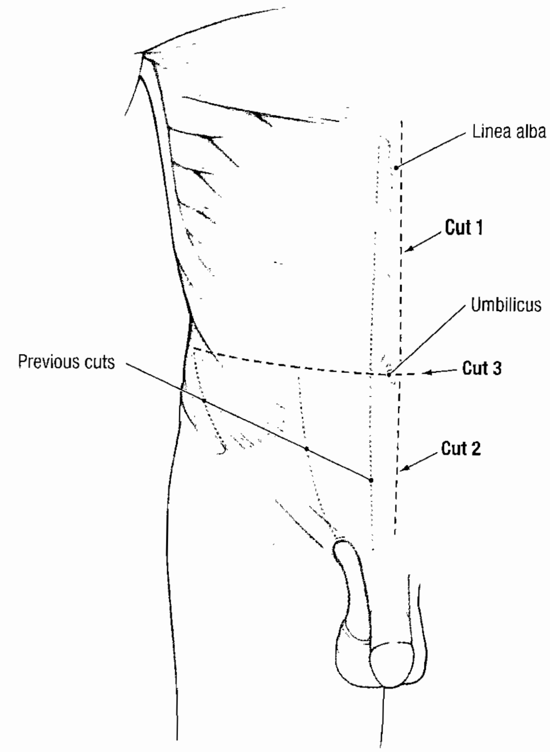


Figure 4.19. Cuts used to open the abdominal cavity.

PERITONEUM AND PERITONEAL CAVITY

Before you dissect . . .

All body cavities (thoracic cavity, pericardium, and abdominopelvic cavity) are lined by a serous membrane, which secretes a small amount of fluid to lubricate the movements of organs. In the abdominal cavity and pelvic cavity this membrane is called the **peritoneum**. There are two types (Fig. 4.20). **Parietal peritoneum** lines the inner surfaces of the abdominal and pelvic walls, and **visceral peritoneum** covers the surfaces of the abdominal and pelvic organs. Between these two types of peritoneum is a potential space called the **peritoneal cavity**.

During development, some organs grow into the peritoneal cavity and become **intraperitoneal** (invested in peritoneum). Examples of intraperitoneal organs include the stomach, small intestine, liver, and spleen. Some organs develop behind the peritoneum and are called **retroperitoneal organs.** The ureters and kidneys are examples. Some parts of the gastrointestinal tract begin as intraperitoneal organs then become attached to the abdominal wall during development. These organs are **secondarily retroperitoneal**. Examples of secondarily retroperitoneal organs include the duodenum, pancreas, ascending colon, and descending colon.

The order of dissection will be as follows. The abdominal viscera will be identified and localized by abdominal quadrant. The named specializations of the peritoneum will be studied. For a more complete understanding, review the development of the gastrointestinal tract before examining the peritoneal specializations.

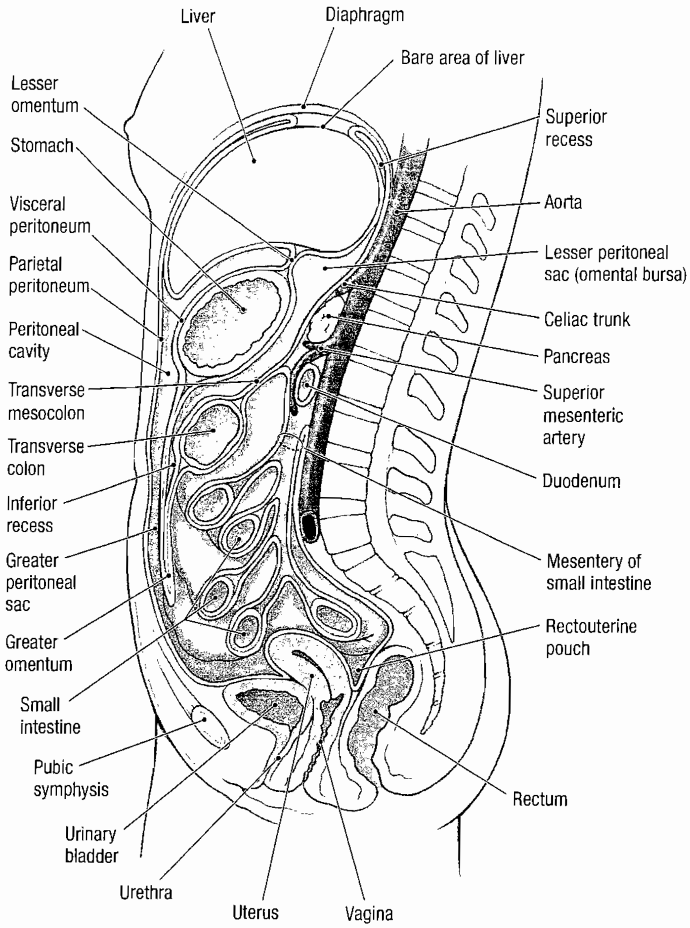


Figure 4.20. Peritoneum and peritoneal cavity, median section.

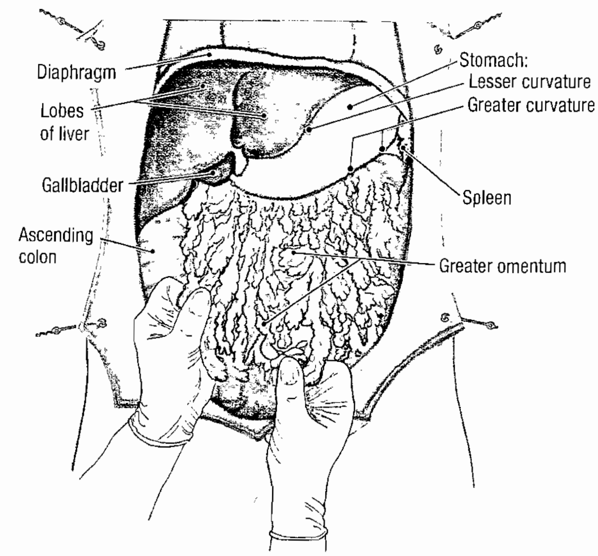


Figure 4.21. The relationship of the greater omentum to the abdominal viscera.

Dissection Instructions

ABDOMINAL VISCERA [G 113, 120; N 261; R 281, 282; C 188]

1. Use your hands to inspect the abdominal cavity. As you perform the inspection, you may encounter adhesions. If adhesions are present, tear them with your fingers.
2. Open the flaps of the abdominal wall. The incision lines correlate to the abdominal quadrant lines. As you examine the organs, you should close and open the flaps to help you relate the organs to the abdominal quadrants. Most of the organs to be identified are parts of the **gastrointestinal tract**.
3. Identify the **liver** (Fig. 4.21). It is an intraperitoneal organ. The liver occupies the right upper quadrant and extends across the midline into the left upper quadrant. The liver lies against the inferior surface of the diaphragm. The attachment of the falciform ligament divides the liver into **right** and **left lobes**.
4. The **gallbladder**, an intraperitoneal organ, is also in the right upper quadrant. The gallbladder extends below the inferior border of the liver. It is usually found at the tip of the right ninth costal cartilage in the midclavicular line. Confirm this relationship.
5. Identify the **stomach**. It is an intraperitoneal organ and lies in the left upper quadrant. It is continuous with the esophagus proximally and the duodenum distally. The liver partially covers the anterior surface of the stomach.
6. Find the **spleen**. It is an intraperitoneal organ, which lies in the left upper quadrant. It is found posterior to the stomach and may be difficult to find unless it is enlarged. Reach around the left side of the stomach with your right hand and palpate the spleen.
7. Identify the **greater omentum** (Fig. 4.21). The greater omentum is attached to the greater curvature of the stomach. Reflect the greater omentum superiorly over the costal margin (Fig. 4.22).
8. Identify the **small intestine** (Figs. 4.22, 4.23). The small intestine begins at the pyloric end of the stomach. It has three parts:
   - **Duodenum**
   - **Jejunum**
   - **Ileum**
9. Most of the duodenum is secondarily retroperitoneal. It will be studied with the pancreas.
10. The **jejunum** and **ileum** are intraperitoneal organs that extend from the left upper quadrant to the right lower quadrant, but because of their length and mobility, they occupy all four quadrants. Beginning in the left upper quadrant, pass the jejunum and ilium between your hands and appreciate its length, position, and termination.
11. Identify the **large intestine**. The large intestine begins in the right lower quadrant at the ileocecal junction (Fig. 4.23). It has six parts:
    - **Cecum** is in the right lower quadrant. The **appendix** is attached to the inferior end of the cecum.
    - **Ascending colon** extends from the right lower quadrant to the right upper quadrant. It ends at the **right colic (hepatic) flexure**. The ascending colon is secondarily retroperitoneal.

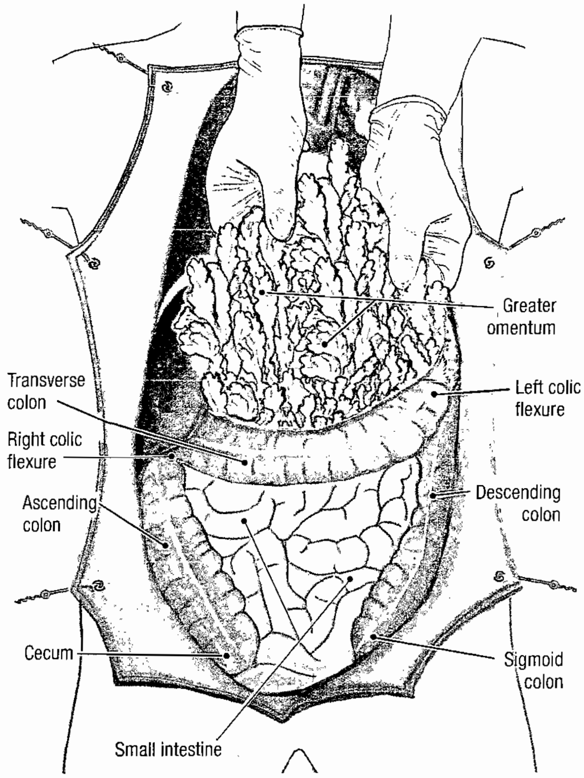


Figure 4.22. Reflect the greater omentum superiorly to expose the small intestine and large intestine.

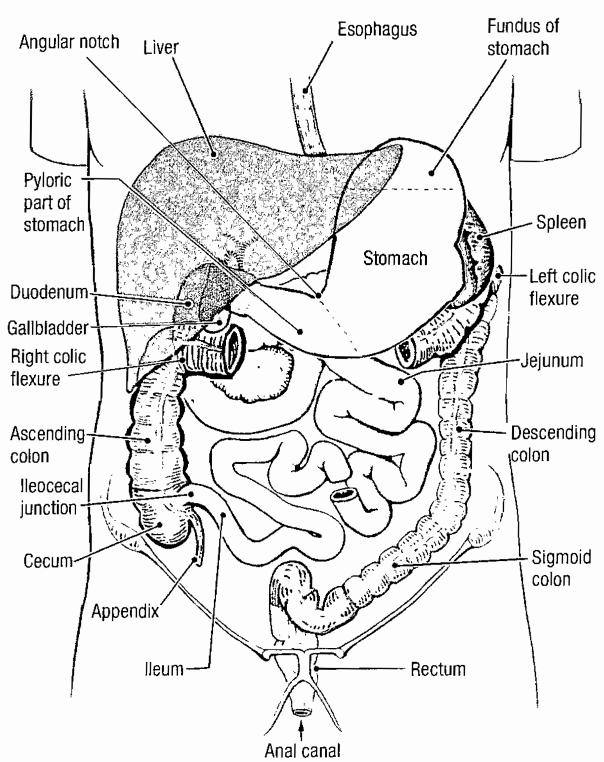


Figure 4.23. Schematic drawing of the abdominal organs. Part of the transverse colon has been removed.

- **Transverse colon** extends from the right upper quadrant to the left upper quadrant. The transverse colon ends at the **left colic (splenic) flexure**. The transverse colon is intraperitoneal.
- **Descending colon** extends from the left upper quadrant to the left lower quadrant. The descending colon is secondarily retroperitoneal.
- **Sigmoid colon** is in the left lower quadrant. The sigmoid colon ends in the pelvic cavity at the level of the third sacral vertebral level. The sigmoid colon is an intraperitoneal organ.
- **Rectum** is the pelvic portion of the gastrointestinal tract. It will be studied with the pelvic viscera.

12. Use your hands to trace the large intestine from the right lower quadrant to the left lower quadrant. Note the position and mobility of each of its parts.

PERITONEUM [G 113; N 261; R 294; C 192]

1. Observe the **visceral peritoneum** on the surface of the stomach or small intestine (Fig. 4.20). Note that visceral peritoneum is smooth and slippery.
2. Observe the **parietal peritoneum** on the inner surface of the abdominal wall (Fig. 4.20). Note that parietal peritoneum is also smooth and slippery.
3. Observe the **greater omentum** (Fig. 4.21). Spread this apron-like structure to appreciate its size. The greater omentum normally lies between the intestines and the anterior abdominal wall (Fig. 4.20). **[G 114; N 267; R 299; C 202]**
4. Elevate the inferior border of the liver and identify the **lesser omentum** (Fig. 4.20). The lesser omentum passes from the lesser curvature of the stomach and first part of the duodenum to the inferior surface of the liver. The lesser omentum has two parts:
   - **Hepatogastric ligament**
   - **Hepatoduodenal ligament**
5. Return the right upper quadrant flap to its anatomical position and review the **falciform ligament**. The falciform ligament passes from the parietal peritoneum on the anterior abdominal wall to the visceral peritoneum on the surface of the liver. The **round ligament of the liver (ligamentum teres hepatis)** is the obliterated umbilical vein, and it is found in the inferior free margin of the falciform ligament.
6. Follow the falciform ligament superiorly to find the **coronary ligament** that attaches the liver to the diaphragm. Two peritoneal ligaments are parts of the coronary ligament:
   - **Left triangular ligament** is between the left lobe of the liver and the diaphragm.
   - **Right triangular ligament** is between the right lobe of the liver and the diaphragm.
7. The **gastrophrenic ligament** connects the superior part of the greater curvature of the stomach to the diaphragm. Slide your hand superiorly to the left of the stomach to feel this ligament.
8. The **gastrosplenic (gastrolienal) ligament** passes from the greater curvature of the stomach to the spleen, and the **splenorenal (lienorenal) ligament**

connects the spleen to the posterior abdominal wall over the left kidney (Fig. 4.24).

9. Reflect the greater omentum superiorly over the costal margin and identify the **transverse mesocolon** (Fig. 4.20). The transverse mesocolon attaches the transverse colon to the posterior abdominal wall. At the left end of the transverse mesocolon is the **phrenicocolic ligament**, which attaches the left colic flexure to the diaphragm. **[N 263; R 294; C 212]**
10. Identify the **mesentery** (Fig. 4.20). The mesentery suspends the jejunum and ileum from the posterior abdominal wall. The root of the mesentery attaches to the posterior abdominal wall from the left upper quadrant to the right lower quadrant.
11. Observe the **mesoappendix**. The mesoappendix attaches the appendix to the posterior abdominal wall and it contains the appendicular artery.
12. Identify the **sigmoid mesocolon** in the lower left quadrant. The sigmoid mesocolon suspends the sigmoid colon from the posterior abdominal wall.
13. Note that these peritoneal structures all are found within a subdivision of the peritoneal cavity called the **greater peritoneal sac** (Fig. 4.20). Posterior to the stomach and lesser omentum is a smaller subdivision of the peritoneal cavity called the **lesser peritoneal sac (omental bursa)** (Fig. 4.24).
14. The **omental foramen (epiploic foramen, foramen of Winslow)** connects the greater and lesser peritoneal sacs. The omental foramen lies posterior to the hepatoduodenal ligament (Fig. 4.24). **[G 114; N 267; R 299; C 220]**
15. Insert your finger into the omental foramen and review its **four boundaries**:
    - **Anterior**—hepatic portal vein, hepatic artery proper, and bile duct contained within the hepatoduodenal ligament (Fig. 4.24)
    - **Posterior**—inferior vena cava and right crus of the diaphragm covered with parietal peritoneum
    - **Superior**—caudate lobe of the liver covered with visceral peritoneum
    - **Inferior**—first part of the duodenum covered with visceral peritoneum
16. Study a diagram of the **lesser peritoneal sac** (Fig. 4.20). The lowest part of the lesser peritoneal sac is called the **inferior recess** and it extends inferiorly as far as the greater omentum. During development, the inferior recess extended between the layers of the greater omentum (review an embryology text). The highest part of the lesser peritoneal sac is the **superior recess.** The diaphragm lies posterior to the superior recess and the caudate lobe of the liver is anterior to the superior recess. **[G 116; N 165; R 301; C 195]**
17. Posterior to the main part of the lesser peritoneal sac is the pancreas (Fig. 4.20). The peritoneum that covers the pancreas forms part of the posterior wall of the lesser peritoneal sac.

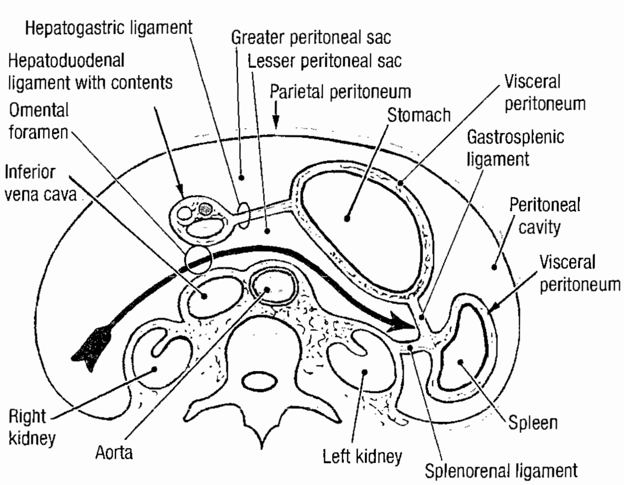


Figure 4.24. Schematic drawing of the peritoneal cavity in transverse section—inferior view. The arrow passes through the omental foramen.

After you dissect . . .

Use the cadaver specimen to review all parts of the gastrointestinal tract in proximal to distal order. State the quadrant(s) in which each abdominal organ normally is found. Review all parts and specializations of the peritoneum listed on the preceding pages. Review the development of the gut tube and mesenteries.

CELIAC TRUNK, STOMACH, SPLEEN, LIVER, AND GALLBLADDER

Before you dissect . . .

The order of dissection will be as follows. The surface features of the stomach will be studied. The vessels and ducts in the hepatoduodenal ligament will be demonstrated. The branches of the celiac trunk that supply the stomach, spleen, liver, and gallbladder will be dissected. The remainder of the field of supply of the celiac trunk (to the duodenum and pancreas) will be dissected later. The hepatic portal vein will be studied. The spleen, liver, and gallbladder will be studied.

Dissection Instructions

1. Place the greater omentum in its correct anatomical position.
2. Identify the parts of the stomach (Fig. 4.25): **[G 121; N 267; R 284; C 198]**
    - **Anterior surface**
    - **Greater curvature**
    - **Lesser curvature**
    - **Cardia**
    - **Cardial notch**
    - **Fundus**
    - **Body**
    - **Angular incisure (notch)**
    - **Pyloric part**
    - **Pylorus**

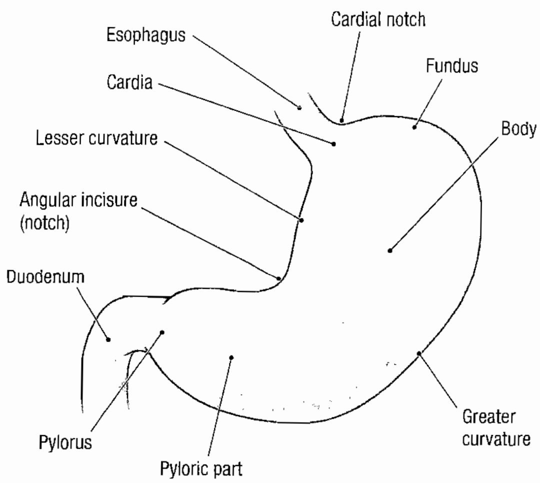


Figure 4.25. Parts of the stomach

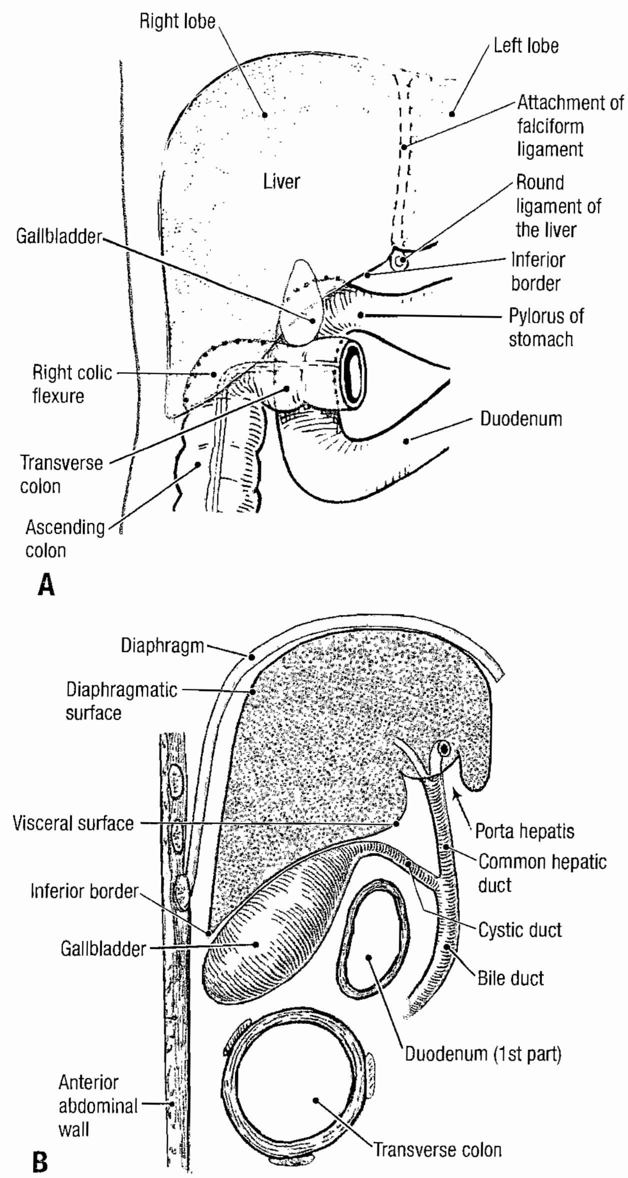


Figure 4.26. Relationships of the gallbladder. **A.** Anterior view. **B.** Sagittal view.

3. Identify the following features of the liver (Fig. 4.26A,B): **[G 142; N 279 ; R 288; C 207]**
   Right lobe
   Left lobe
   Diaphragmatic surface
   Inferior border
4. Use your hand to raise the inferior border of the liver. Identify the **visceral surface of the liver** (Fig. 4.26B). The visceral surface is in contact with the gallbladder and the peritoneum covering the stomach, duodenum, colon, right kidney, and right suprarenal gland.
5. Identify the **porta hepatis** on the visceral surface of the liver. It is the fissure through which vessels, ducts, lymphatics, and nerves enter the liver (Fig. 4.26B). **[G 143; N 279; R 289; C 207]**
6. Identify the **gallbladder** (Fig.4.26B). The gallbladder may have been surgically removed.

CELIAC TRUNK [G 128; N 292; R 303; C 196]

As you dissect the branches of the celiac trunk, realize that *arteries are named by their region of distribution, not by their origin or branching pattern.*

1. Insert your finger into the omental foramen. Anterior to your finger is the **hepatoduodenal ligament** and its contents: **bile ducts, hepatic artery proper, hepatic portal vein, autonomic nerves**, and **lymphatics**.
2. To aid dissection, place a strip of white paper into the omental foramen (Fig. 4.27).
3. Use blunt dissection to remove the peritoneum from the anterior surface of the hepatoduodenal ligament (anterior to the vessels and ducts).
4. Identify the three large structures that are contained within the hepatoduodenal ligament: **(common) bile duct, hepatic artery proper**, and **hepatic portal vein** (Fig. 4.27). The bile duct is the most lateral of the three.
5. Use a probe to trace the bile duct superiorly. Identify the **cystic duct** and the **common hepatic duct** (Fig. 4.28).

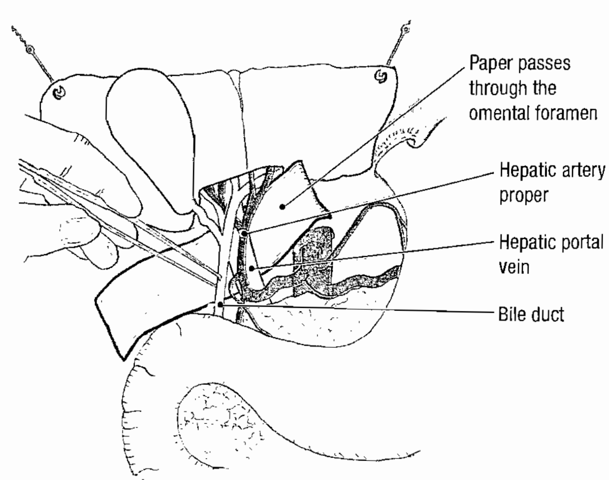


Figure 4.27. Structures contained within the hepatoduodenal ligament.

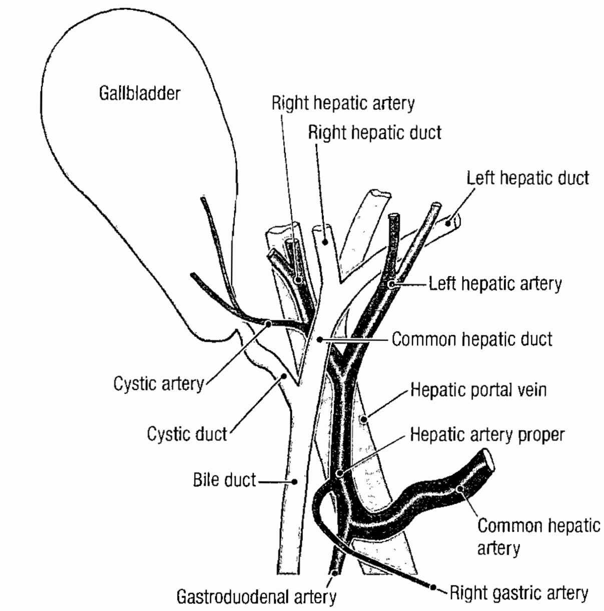


Figure 4.28. Structures contained within the hepatoduodenal ligament. Tributaries of the (common) bile duct and branches of the common hepatic artery.

6. Follow the common hepatic duct superiorly until it receives its tributaries, the **right hepatic duct** and the **left hepatic duct.** The right and left hepatic ducts exit the **porta hepatis.**
7. Clean the **hepatic artery proper.** The tough "connective tissue" around these vessels contains an **autonomic nerve plexus.** To clear the dissection field, remove the autonomic nerves. **[G 122; N 290; R 303; C 196]**
8. Follow the hepatic artery proper through the hepatoduodenal ligament to the porta hepatis where it branches into the **left hepatic artery** and the **right hepatic artery** (Fig. 4.28).
9. Two other arteries arise in the hepatoduodenal ligament (Fig. 4.28):
   - **Cystic artery**—arises from the right hepatic artery. Follow it to the gallbladder.
   - **Right gastric artery**—arises from the hepatic artery proper. Follow it to the lesser curvature of the stomach.
10. **Lymphatics** are also contained within the hepatoduodenal ligament. The lymphatic vessels are too small to dissect but **hepatic lymph nodes** can be seen. The lymph nodes may be removed to clear the dissection field.
11. Follow the hepatic artery proper inferiorly and confirm that it is the continuation of the **common hepatic artery** (Fig. 4.28).
12. Observe that the common hepatic artery gives rise to the **gastroduodenal artery.** The gastroduodenal artery passes posterior to the first part of the duodenum (Fig. 4.29). Follow the gastroduodenal artery until it divides to give rise to the **right gastro-omental (gastroepiploic) artery** and the **superior pancreaticoduodenal artery.**

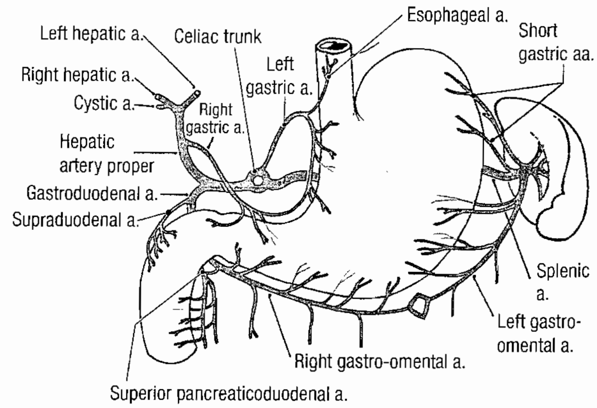


Figure 4.29. Schematic drawing of the branches of the celiac trunk.

CLINICAL CORRELATION

Anatomical Variation in Arteries

In approximately 12% of cases, the right hepatic artery arises from the superior mesenteric artery. An aberrant left hepatic artery may arise from the left gastric artery. During gastrectomy (surgical removal of the stomach), blood flow to an aberrant left hepatic artery could be interrupted, endangering the left lobe of the liver. The cystic artery usually arises from the right hepatic artery, but other origins are possible. The cystic artery may pass posterior (75%) or anterior (24%) to the common hepatic duct (Fig. 4.30).

13. Follow the common hepatic artery to the left toward the **celiac trunk** (Fig. 4.29). Note that the celiac trunk arises from the anterior surface of the abdominal aorta at the level of the twelfth thoracic vertebra. The celiac trunk is very short (less than 2 cm in most cases) and divides into three branches:
    - **Common hepatic artery** (already dissected)
    - **Left gastric artery**
    - **Splenic artery**
14. Use blunt dissection to follow the **left gastric artery** (Fig. 4.29). The left gastric artery reaches the stomach near the esophagus and then follows the lesser curva-

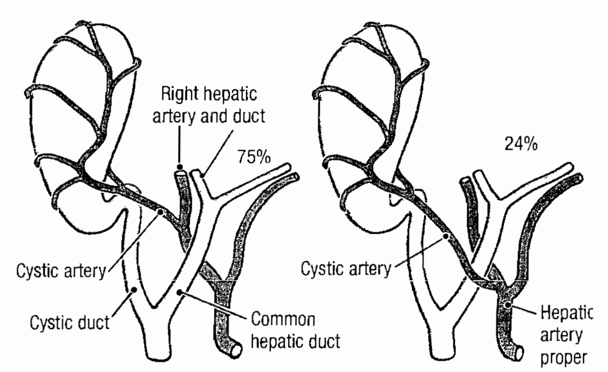


Figure 4.30. The two most common branching patterns of the cystic artery.

ture of the stomach within the lesser omentum. The left gastric artery forms an anastomosis with the right gastric artery along the lesser curvature of the stomach. Branches of the gastric arteries distribute to the anterior and posterior surfaces of the stomach.

15. Follow the **splenic artery** to the left for approximately 5 cm and verify that it lies against the posterior abdominal wall. The splenic artery courses along the superior border of the pancreas and may be partially imbedded in it. Do not dissect the splenic artery from the pancreas at this time. Note that **short gastric arteries** arise from the splenic artery to supply the fundus of the stomach (Fig. 4.29).
16. Find the **left gastro-omental (gastroepiploic) artery** in the greater omentum approximately 2 cm from the greater curvature of the stomach (Fig. 4.29). The left gastro-omental artery is a branch of the splenic artery.
17. Find the **right gastro-omental artery** in the greater omentum near the right end of the greater curvature of the stomach. The right gastro-omental artery anastomoses with the left gastro-omental artery. Follow the right gastro-omental artery to the right to find its origin from the gastroduodenal branch of the common hepatic artery. **[G 128; N 292; R 302; C 196]**
18. Return to the hepatoduodenal ligament and identify the **hepatic portal vein**. The hepatic portal vein lies posterior to both the hepatic artery proper and the bile duct (Fig. 4.27). Follow the hepatic portal vein superiorly and observe that it passes into the porta hepatis where it divides into **right and left portal veins**. The hepatic portal vein usually receives the **left and right gastric veins** as tributaries. Inferiorly, the hepatic portal vein passes posterior to the first part of the duodenum.

SPLEEN [G 123; N 289; R 305; C 202]

The spleen is the largest hematopoietic organ in the body. Its size and weight may vary considerably depending upon the blood volume that it contains. The spleen is covered by visceral peritoneum except at the hilum where the splenic vessels enter and leave.

1. Use your left hand to pull the fundus of the stomach to the right. Use your right hand to gently pull the spleen anteriorly.
2. Observe that the spleen has a smooth diaphragmatic surface. The spleen has sharp anterior, inferior, and superior borders. The superior border of the spleen is often notched.
3. The **visceral surface of the spleen** is related to four organs:
   - **Stomach**
   - **Left kidney**
   - **Transverse colon (left colic flexure)**
   - **Pancreas**
4. The **diaphragmatic surface of the spleen** is related (through the diaphragm) to ribs 9, 10, and 11 (Fig. 4.31).

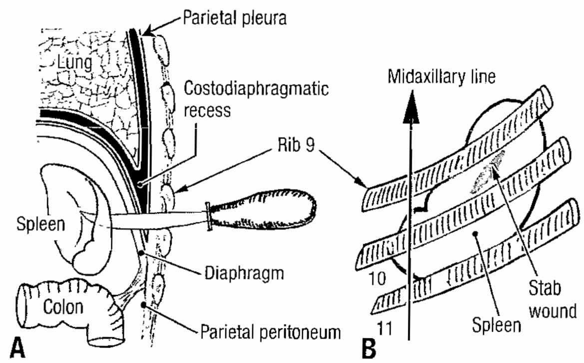


Figure 4.31. Relationships of the spleen to the thoracic wall. **A.** Frontal section. **B.** Lateral view. A penetrating wound through the ninth intercostal space, just posterior to the midaxillary line, will penetrate the pleural cavity, diaphragm, peritoneal cavity, and spleen

CLINICAL CORRELATION

Spleen

The relationship of the spleen to ribs 9, 10, and 11 is of clinical importance in evaluating rib fractures and penetrating wounds. A lacerated spleen bleeds profusely into the abdominal cavity and may have to be removed surgically (splenectomy). It must be emphasized that there is a risk of puncturing the spleen during thoracocentesis (pleural tap).

An enlarged spleen (splenomegaly) may be encountered during physical examination. The spleen is considered enlarged when it can be palpated inferior to the costal margin.

LIVER [G 142; N 279; R 288; C 206]

The **liver** is the largest gland in the body, comprising approximately 2.5% of the body weight of an adult. To study the surface features of the liver, it must be detached from the diaphragm.

1. Review the falciform ligament and the coronary ligament of the liver.
2. Use scissors to cut the falciform ligament along its attachment to the anterior abdominal wall. Extend the cut superiorly and cut the right and left triangular ligaments along the inferior surface of the diaphragm.
3. Insert your fingers between the liver and the diaphragm and free the connective tissue attachment of the liver to the diaphragm. Cut the posterior layer of the coronary ligament.
4. Use scissors to cut the inferior vena cava between the liver and the diaphragm. Elevate the inferior border of the liver and cut the inferior vena cava again, as close to the inferior surface of the liver as possible. These two cuts will leave a short segment of the inferior vena cava within the liver (Fig. 4.32B).
5. The liver should now be freely mobile but attached to the other abdominal viscera by the bile duct, hepatic artery proper, and hepatic portal vein. Move the liver carefully to avoid tearing these structures.

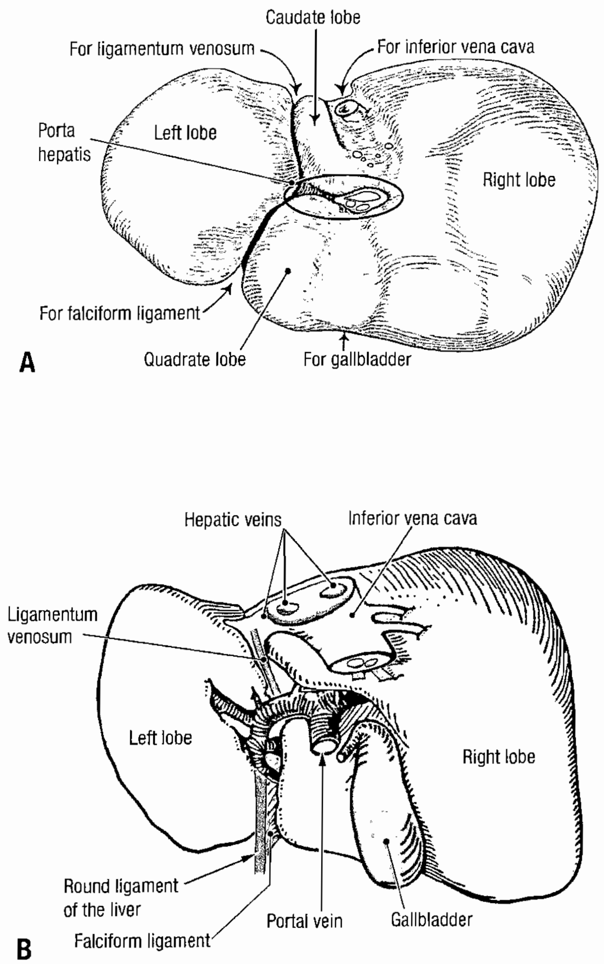


Figure 4.32. Posterior views of the liver. **A.** Fissures and sulci define the four lobes of the liver (right, left, quadrate, and caudate). **B.** Structures located in the H-shaped fissures.

6. Examine the **liver** and note that the **right lobe** is six times larger than the **left lobe**. The sharp **inferior border** of the liver separates the **visceral surface** from the **diaphragmatic surface**.
7. Identify the **bare area** on the posterior aspect of the diaphragmatic surface. Here, the liver was adjacent to the diaphragm and not covered by peritoneum. Around the bare area, note the cut edges of the **coronary ligament**.
8. Examine the **visceral surface** of the liver (Fig. 4.32A). An H-shaped set of fissures and fossae defines four lobes. Identify the **right lobe, left lobe, caudate lobe**, and **quadrate lobe. [G 143, 148; N 279; R 289; C 207]**
9. Observe that the **ligamentum venosum** and **falciform ligament** occupy the left fissure of the "H" (Fig. 4.32B). The **gallbladder** and **inferior vena cava** occupy the fossae that form the right side of the "H."
10. Identify the **porta hepatis.** It forms the horizontal bar of the "H." The structures passing through the hepatoduodenal ligament (bile ducts, hepatic arteries, hepatic portal vein, lymphatics, and autonomic nerves) enter or leave the liver at the porta hepatis.
11. Examine the small segment of the **inferior vena cava** that is attached to the liver. Note that several **hepatic veins** drain directly into the inferior vena cava (Fig. 4.32B).
12. Use a textbook to study the two conventions by which the liver may be divided into lobes. The falciform ligament divides the liver into **right and left anatomical lobes.** The pattern of its bile drainage and vascular supply are used to divide the liver into **right and left functional lobes. [G 146; N 281; R 289]**
13. The liver has a substantial lymphatic drainage. At the porta hepatis, small lymph vessels drain into **hepatic lymph nodes.** From the hepatic lymph nodes, lymphatic vessels follow the hepatic arteries to **celiac lymph nodes** located around the celiac trunk.

CLINICAL CORRELATION

Liver

The liver may undergo pathologic changes that could be encountered during dissection. The liver may be enlarged. This happens in liver congestion because of cardiac insufficiency (cardiac liver). In contrast, the liver may be small and have fibrous nodules. Such a finding may indicate cirrhosis of the liver. Because the liver is essentially a capillary bed downstream from the gastrointestinal tract, metastatic tumor cells are often trapped within it, resulting in secondary tumors.

GALLBLADDER [G 148; N 285; R 287; C 208]

The gallbladder is a reservoir for the storage and concentration of bile. The gallbladder occupies a shallow fossa on the visceral surface of the liver (Fig. 4.32B). The gallbladder is usually stained dark green by bile, which leaks through the wall of the gallbladder after death.

1. Replace the liver into its correct anatomical position.
2. Confirm that the gallbladder is located near the tip of the ninth costal cartilage in the midclavicular line.
3. Reposition the liver to expose the visceral surface. Use blunt dissection to remove the gallbladder from its fossa.
4. Identify the parts of the gallbladder (Fig. 4.33):
   - **Fundus**
   - **Body**
   - **Neck**
5. Review the course of the **cystic artery.** The cystic artery is stained green by bile and is often fragile and difficult to dissect.
6. Use scissors to make a longitudinal incision through the wall of the gallbladder, beginning at the fundus and continuing through the neck. If gallstones are present, remove them. Look for the **spiral fold,** which is present in the mucosal lining of the neck, continuing into the **cystic duct.**

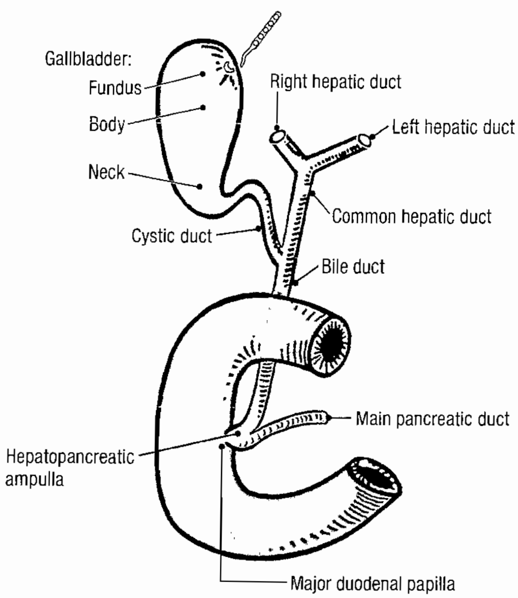


Figure 4.33. Extrahepatic bile ducts.

After you dissect . . .

Replace the organs in their correct anatomical positions. Close and open the flaps of the abdominal wall and review the location of each organ relative to the abdominal quadrant system. Use an illustration and the dissected specimen to trace the branches of the celiac trunk. Review the relationships of the structures in the hepatoduodenal ligament. Review the boundaries of the omental foramen. Review the parts of the organs dissected and their relationships to surrounding structures. Use an embryology textbook to review the development of the liver and the ventral mesogastrium. Review the derivatives of the embryonic foregut.

SUPERIOR MESENTERIC ARTERY AND SMALL INTESTINE

Before you dissect . . .

The order of dissection will be as follows. The mesentery will be examined. The branches of the superior mesenteric artery that supply the jejunum, ileum, cecum, ascending colon, and transverse colon will be dissected. The remainder of the field of supply of the superior mesenteric artery (to the duodenum and pancreas) will be dissected later, because these structures lie behind the attachment of the transverse mesocolon. The external features of the jejunum and ileum will be studied. The inferior mesenteric vessels will be dissected.

Dissection Instructions

SUPERIOR MESENTERIC ARTERY [G 136; N 295, 296; R 291; C 216]

The superior mesenteric artery arises from the anterior surface of the abdominal aorta approximately 1 cm inferior to the celiac trunk. At its origin, the superior mesenteric artery lies posterior to the neck of the pancreas. When the superior mesenteric artery emerges from posterior to the neck of the pancreas, it passes anterior to the uncinate process, third part of the duodenum, and left renal vein. The superior mesenteric artery then enters the mesentery. Within the mesentery the superior mesenteric artery courses toward the terminal end of the ileum.

1. Return the liver to its correct anatomical position.
2. Turn the transverse colon and greater omentum superiorly over the costal margin. The posterior surface of the transverse mesocolon should face anteriorly.
3. Move the coils of the **jejunum** and **ileum** to the left side of the abdomen so that the right side of the mesentery faces anteriorly (Fig. 4.34). Observe that the root of the mesentery is attached to the posterior abdominal wall along a line from the left upper quadrant to the right lower quadrant.
4. Remove the peritoneum on the right side of the mesentery to expose the branches of the superior mesenteric artery. To do this, use a probe to tear the peritoneum, then grasp it between your thumb and index finger (Fig. 4.35). Peel it slowly, using the handle of a forceps to scrape the peritoneum free from deeper structures.
5. Remove the parietal peritoneum from the posterior abdominal wall on the right side of the mesentery. Remove the peritoneum as far laterally as the ascending colon.
6. Identify the **superior mesenteric artery**. Use blunt dissection to trace the superior mesenteric artery proximally and observe that it crosses anterior to the third part of the duodenum. Note that the third part of the duodenum and the left renal vein can become compressed between the superior mesenteric vessels and the abdominal aorta.
7. Use blunt dissection to clean the branches of the superior mesenteric artery. As you dissect, note the dense autonomic nerve network surrounding the vessels. This is the **superior mesenteric plexus of nerves**. Remove the nerves as necessary to clear the dissection field.

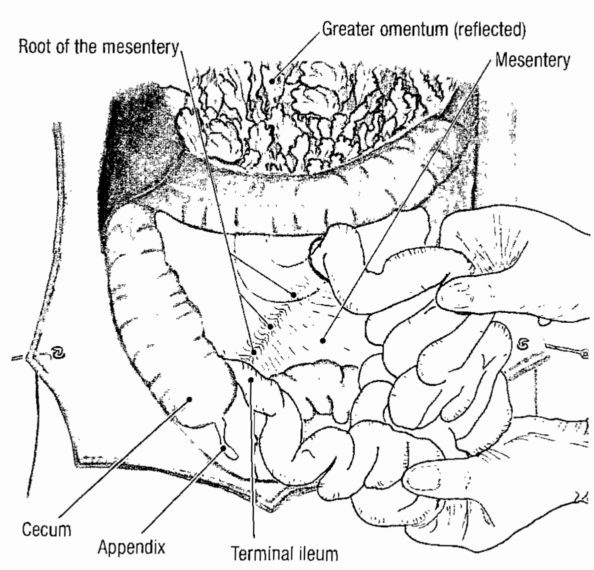


Figure 4.34. Move the small intestine to the left for dissection of the superior mesenteric artery.

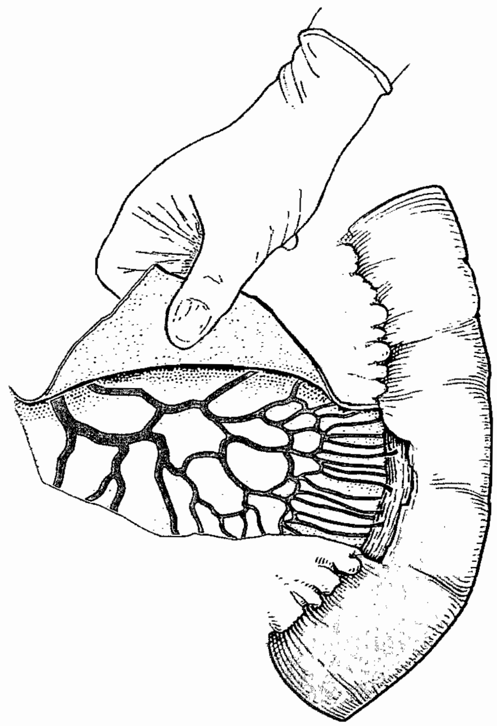


Figure 4.35. How to remove the peritoneum from the mesentery to expose the blood vessels.

8. Identify the **branches of the superior mesenteric artery**:
   - **Inferior pancreaticoduodenal artery** – the first branch of the superior mesenteric artery. The inferior pancreaticoduodenal artery will be dissected later.
   - **Intestinal arteries** – 15 to 18 arteries to the jejunum and the ileum. Intestinal arteries end in straight terminal branches called **vasa recta** (Fig. 4.36). **Arcades** connect the intestinal arteries. Observe the blood supply to the proximal jejunum and note that only one or two arcades are found between adjacent intestinal arteries, resulting in relatively long vasa recta (Fig. 4.36A). Examine the distal ileum and note that four or five arcades occur between adjacent intestinal arteries, resulting in relatively short vasa recta (Fig. 4.36B).
   - **Ileocolic artery** – supplies the cecum. The ileocolic artery gives rise to the **appendicular artery** (Fig. 4.37). The ileocolic artery anastomoses with intestinal branches and with the right colic artery.
   - **Right colic artery** – supplies the ascending colon. The right colic artery arises from the right side of the superior mesenteric artery and passes to the right in a retroperitoneal position. It divides into a superior branch and an inferior branch.
   - **Middle colic artery** – supplies the transverse colon. The middle colic artery arises from the anterior surface of the superior mesenteric artery and courses through the transverse mesocolon. It divides into a right branch and a left branch.
9. Identify the **superior mesenteric vein.** The superior mesenteric vein is formed by branches that correspond in name and position to the branches of the superior mesenteric artery. The superior mesenteric vein courses along the right side of the superior mesenteric artery. Posterior to the pancreas, the superior mesenteric vein joins the splenic vein to form the **hepatic portal vein.**
10. The mesentery may contain up to 200 **mesenteric lymph nodes.** Identify one or two of these lymph nodes along the branches of the superior mesenteric vessels. The **superior mesenteric lymph nodes** are located near the origin of the superior mesenteric artery from the abdominal aorta. Lymph nodes may be removed to clear the dissection field.

SMALL INTESTINE [G 132, 133; N 262; R 298; C 218]

The small intestine consists of the duodenum, jejunum, and ileum. The function of the small intestine is to absorb nutrients from food. It has elaborate folds of mucosa that increase surface area and a rich blood supply to transport the absorbed nutrients. The **jejunum** (proximal two-

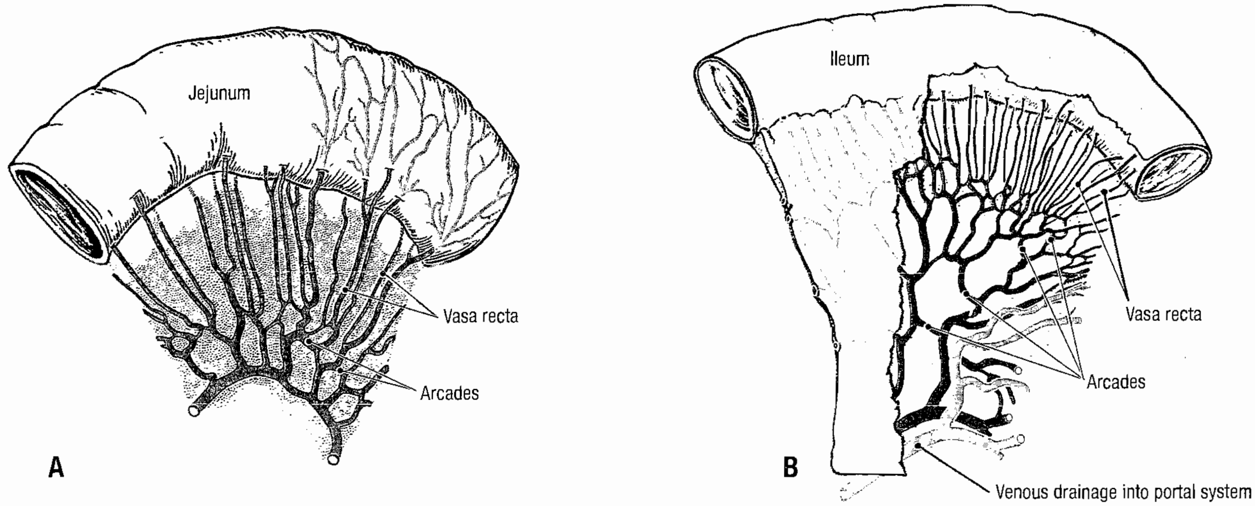


Figure 4.36. Comparison of intestinal arteries. **A.** Arteries of the jejunum. **B.** Arteries of the ileum.

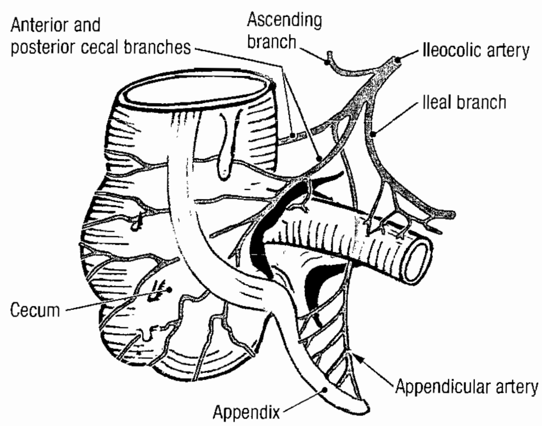


Figure 4.37. Branches of the ileocolic artery.

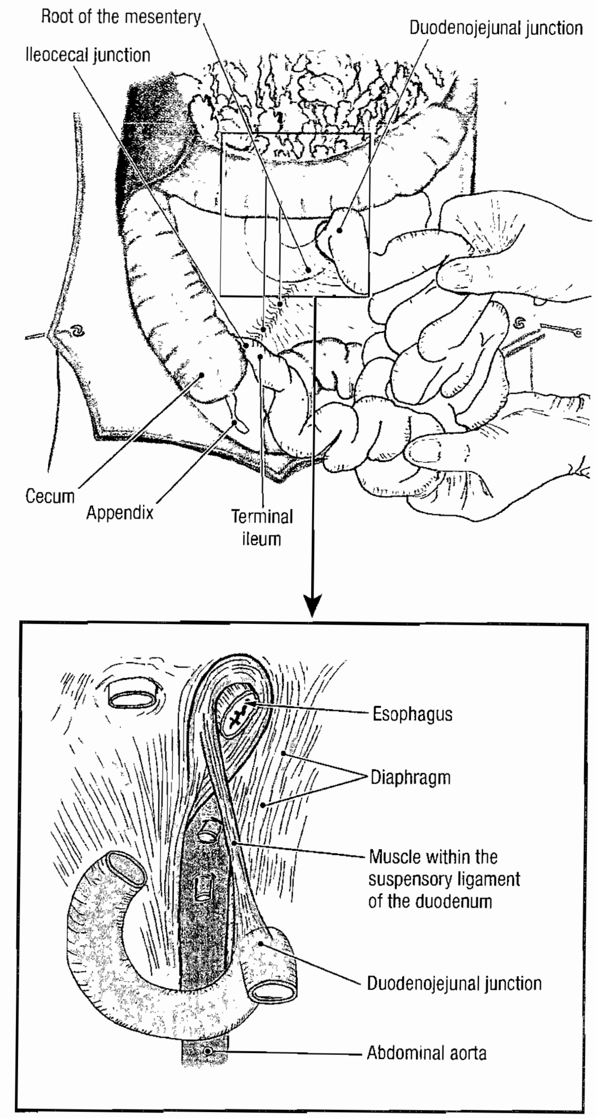


Figure 4.38. Move the small intestine to the left side to find the duodenojejunal junction. Inset: The duodenojejunal junction is suspended by the suspensory muscle (ligament) of the duodenum.

fifths) and **ileum** (distal three-fifths) are studied together because their transition is not obvious.

1. Move the small intestine to the left side of the abdominal cavity and follow the jejunum proximally (Fig. 4.38). Find the **duodenojejunal junction.**
2. Note that the **suspensory ligament of the duodenum** is a fibromuscular ligament that arises from the right crus of the diaphragm and anchors the intestine at the duodenojejunal junction (Fig. 4.38, inset).
3. Palpate the small intestine and note that the wall of the jejunum is thicker than the wall of the ileum.
4. Identify the termination of the ileum where it empties into the **cecum** at the **ileocecal junction** (Fig. 4.38).
5. Verify that the **root of the mesentery** crosses the posterior abdominal wall from the duodenojejunal junction to the ileocecal junction (Fig. 4.38). The root of the mesentery is approximately 15 cm long. The **intestinal attachment of the mesentery** is nearly 6 m long.

After you dissect . . .

Replace the small intestine in its correct anatomical position. Close and open the flaps of the abdominal wall and review the location of the jejunum and ileum relative to the abdominal quadrant system. Review the relationships of the jejunum and ileum to surrounding structures. Use an illustration and the dissected specimen to review the branches of the superior mesenteric artery. Use an embryology textbook to review the derivatives of the embryonic midgut.

INFERIOR MESENTERIC ARTERY AND LARGE INTESTINE

Before you dissect . . .

The **inferior mesenteric artery** arises from the anterior surface of the abdominal aorta at the level of the intervertebral disk between vertebrae L2 and L3. The objective is to demonstrate the field of supply of the inferior mesenteric artery (left half of the transverse colon, descending colon, sigmoid colon, and most of the rectum). Except for the branches that pass through the sigmoid mesocolon to supply the sigmoid colon, the inferior mesenteric artery and its branches lie retroperitoneally.

The order of dissection will be as follows. The inferior mesenteric artery and its branches will be dissected. The external features of the large intestine will be studied.

Dissection Instructions

INFERIOR MESENTERIC ARTERY [G 138; N 296; R 293; C 218]

1. Turn the transverse colon and greater omentum superiorly over the costal margin to expose the posterior surface of the transverse mesocolon.
2. Move the small intestine to the right so that the descending colon is visible from the left colic flexure to the sigmoid colon (Fig. 4.39).

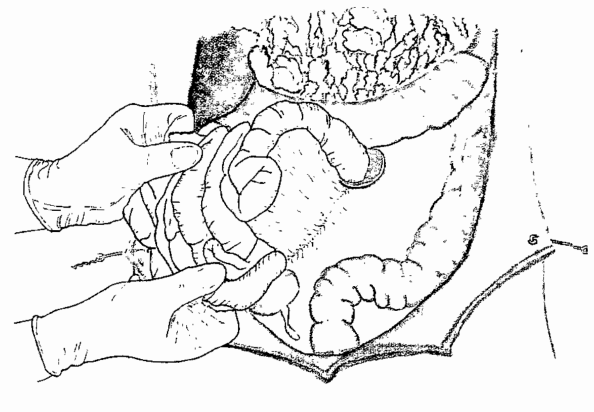


Figure 4.39. Move the small intestine to the right for dissection of the inferior mesenteric artery.

3. The origin of the inferior mesenteric artery lies posterior to the third part of the duodenum. If you have trouble finding it, find one of its branches in the sigmoid mesocolon and trace the branch back to the main vessel. Then proceed with the dissection of the peripheral branches.

Dissection note: The left ureter could be mistaken for the inferior mesenteric artery or one of its branches. The inferior mesenteric artery and vein and the ureter all lie in the retroperitoneal space, but the vessels pass anterior to the ureter.

4. Use a probe to clean the **branches of the inferior mesenteric artery** (Fig. 4.40):
   - **Left colic artery** – supplies the descending colon and the left half of the transverse colon. The left colic artery anastomoses with the middle colic branch of the superior mesenteric artery.
   - **Sigmoid arteries** – supply the sigmoid colon. Sigmoid arteries pass through the sigmoid mesocolon. Note that they form arcades similar to those of the intestinal arteries.
   - **Superior rectal artery** – supplies the proximal part of the rectum. The superior rectal artery divides into a **right branch** and a **left branch**. The right and left branches of the superior rectal artery descend into the pelvis on either side of the rectum. Do not follow them into the pelvis.
5. Observe the tributaries of the **inferior mesenteric vein.** The tributaries of the inferior mesenteric vein correspond to the branches of the inferior mesenteric artery. The inferior mesenteric vein ascends on the left side of the inferior mesenteric artery, passes posterior to the pancreas, and joins either the **splenic vein** or (less frequently) the **superior mesenteric vein.**
6. The inferior mesenteric artery and vein are accompanied by lymph vessels that drain into the **inferior mesenteric nodes** around the origin of the inferior mesenteric artery.

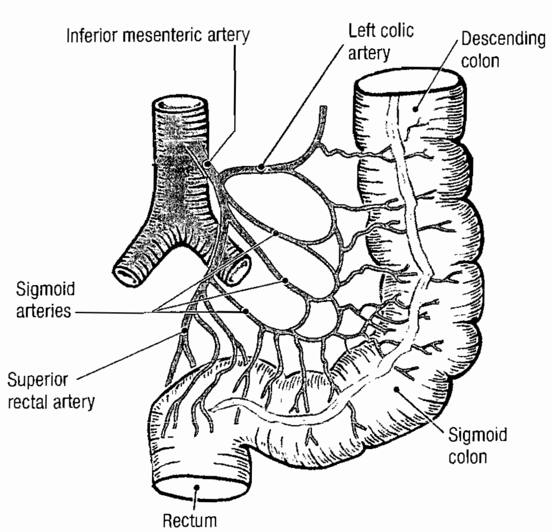


Figure 4.40. Branches of the inferior mesenteric artery.

LARGE INTESTINE [G 132, 133; N 276; R 295; C 212, 214]

The large intestine consists of the **cecum** (with attached **appendix**), **colon** (ascending, transverse, descending and sigmoid), **rectum**, and **anal canal**. Absorption of water from fecal material is a major function of the large intestine. The relatively smooth mucosal surface of the large intestine is well-suited for this function, because a smooth surface is less likely to impede the movement of progressively more solid fecal matter.

1. Return the small intestine and transverse colon to their correct anatomical positions.
2. In the right lower quadrant, identify the **cecum** (L. *caecus*, blind). The length of its mesentery and the degree of its mobility vary considerably from individual to individual.
3. The **appendix (vermiform appendix)** (L. *appendere*, to hang on) is attached to the end of the cecum. The appendix may be found in one of several positions (Fig. 4.41). Recall that the appendix is suspended on a mesentery called the **mesoappendix**. The **appendicular artery** is found within the mesoappendix (Fig. 4.37).
4. Identify the **ascending colon**. It is a secondarily retroperitoneal organ. The ascending colon extends from the cecum to the **right colic flexure** (Fig. 4.23).

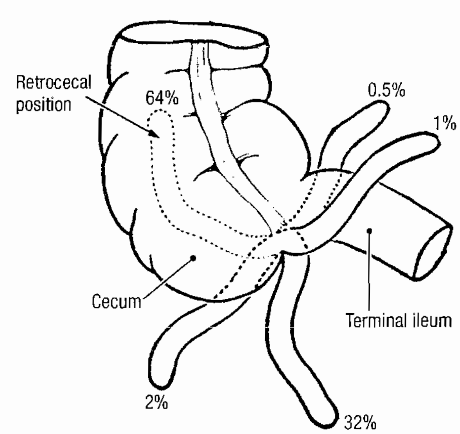


Figure 4.41. Variations in the position of the appendix.

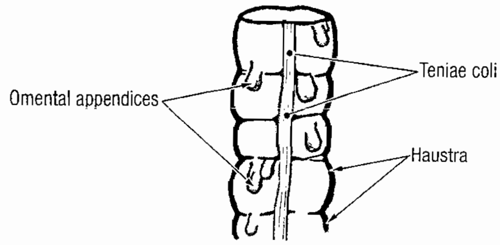


Figure 4.42. Surface features of the large intestine.

5. Identify the **transverse colon**. The transverse colon extends from the **right colic flexure** to the **left colic flexure**. Observe that the left colic flexure is at a more superior level than the right colic flexure. Between the two flexures, the transverse colon is freely movable.
6. Observe the **descending colon.** It is a secondarily retroperitoneal organ. The descending colon descends from the left colic flexure to the left lower quadrant (Fig. 4.23).
7. In the left lower quadrant, find the **sigmoid colon**. Observe that the sigmoid colon has a mesentery (**sigmoid mesocolon**) and is mobile. The sigmoid colon ends in the pelvis at the level of the 3rd sacral segment, where it becomes continuous with the rectum.
8. The **rectum** is contained entirely within the pelvic cavity and will be dissected at a later time.
9. Observe the external surface of the large intestine and note three features that distinguish it from the small intestine (Fig. 4.42):
   - **Teniae coli** – three narrow bands of longitudinal muscle
   - **Haustra** – outpouchings of the wall of the colon
   - **Omental appendices (epiploic appendages)** – small accumulations of fat covered by visceral peritoneum
10. Review the branches of the superior mesenteric artery and inferior mesenteric artery that supply the large intestine. **[G 141; N 296; R 296; C 216, 218]**

After you dissect . . .

Close and open the flaps of the abdominal wall to review the location of each part of the large intestine relative to the abdominal quadrant system. Review the relationship of each part of the large intestine to the surrounding structures. Use an illustration and the dissected specimen to trace the branches of the inferior mesenteric artery. Use an embryology textbook to review the derivatives of the embryonic hindgut.

DUODENUM, PANCREAS, AND HEPATIC PORTAL VEIN

Before you dissect . . .

The duodenum is the part of the small intestine between the stomach and the jejunum. The duodenum is the drainage point for the ducts of the liver and pancreas. The pancreas lies within the bend of the duodenum. The pancreas is both an endocrine and an exocrine organ and has a rich blood supply arising from the celiac trunk and the superior mesenteric artery.

The order of dissection will be as follows. The parts of the duodenum will be studied. The pancreas will be dissected. The formation of the hepatic portal vein will be demonstrated.

Dissection Instructions

DUODENUM [G 125, 126; N 270; R 304; C 210]

1. Turn the transverse colon and greater omentum superiorly over the costal margin.
2. Use blunt dissection to remove the remaining connective tissue and peritoneum from the anterior surface of the duodenum and pancreas.
3. Observe the **four parts of the duodenum** (Fig. 4.43):
   - **Superior (first) part** – at the level of vertebra L1. The superior part of the duodenum lies in the transverse plane and the hepatoduodenal ligament is attached to it. It is mostly intraperitoneal.
   - **Descending (second) part** – at the level of vertebra L2. The descending part of the duodenum is positioned to the right of the midline and anterior to the right kidney, right renal vessels, and inferior vena cava. It is retroperitoneal. The bile duct and the pancreatic duct drain into the descending part of the duodenum.
   - **Horizontal (third) part** – at the level of vertebra L3. The horizontal part of the duodenum lies anterior to the inferior vena cava and the abdominal aorta. It is retroperitoneal. The horizontal part of the duodenum is crossed anteriorly by the superior mesenteric vessels and posteriorly by the inferior mesenteric vessels.
   - **Ascending (fourth) part** – ascends to the level of vertebra L2. The ascending part of the duodenum is retroperitoneal throughout most of its length. The ascending part of the duodenum turns anteriorly to join the jejunum at the duodenojejunal junction.

PANCREAS [G 125, 130; N 288; R 305; C 211]

1. Identify the **pancreas** within the bend of the duodenum. Note that it is a secondarily retroperitoneal organ that lies across the midline and that it is positioned against the vertebral bodies.

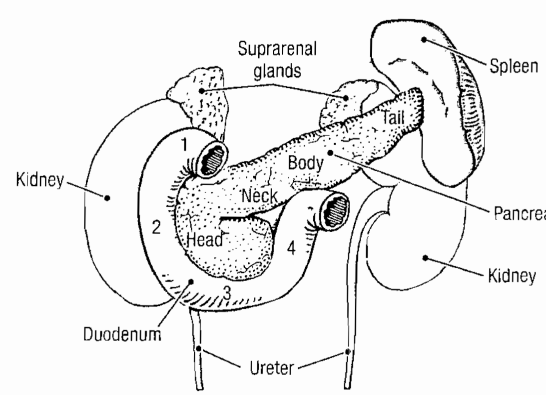


Figure 4.43. Relationships of the spleen, pancreas, duodenum, and kidneys.

2. Identify the parts of the pancreas (Fig. 4.43):
   - **Head** – lies within the curve of the duodenum. The head of the pancreas lies anterior to the origin of the superior mesenteric artery. The **uncinate process** is a small projection from the inferior margin of the head that passes posterior to the superior mesenteric vessels. The inferior vena cava lies posterior to the head of the pancreas.
   - **Neck** – a short portion that lies anterior to the superior mesenteric vessels and connects the head of the pancreas to the body.
   - **Body** – extends from right to left and slightly superiorly as it crosses the posterior abdominal wall. The abdominal aorta lies posterior to the body of the pancreas.
   - **Tail** – the narrow left end of the gland. The tip of the tail lies in the splenorenal ligament and contacts the hilum of the spleen.
3. Use a probe to dissect into the anterior surface of the head of the pancreas and find the **main pancreatic duct.** Trace the main pancreatic duct through the neck and into the body. The **accessory pancreatic duct** joins the main pancreatic duct from the superior side.
4. Follow the main pancreatic duct toward the descending part of the duodenum. Observe that the main pancreatic duct is joined by the bile duct.
5. Identify the **superior pancreaticoduodenal artery** (Fig. 4.44), a branch of the gastroduodenal artery. **[G 127; N 291; R 304; C 213]**
6. The **inferior pancreaticoduodenal artery** is usually the most proximal branch of the superior mesenteric artery, although its origin is variable (Fig. 4.44). The inferior pancreaticoduodenal artery enters the inferior portion of the head of the pancreas.
7. Return to the celiac trunk and follow the splenic artery as it passes to the left along the superior margin of the pancreas (Fig. 4.44). The splenic artery will supply up to 10 small arteries to the body and tail of the pancreas. Identify only two:
   - **Dorsal pancreatic artery** – enters the neck of the pancreas.

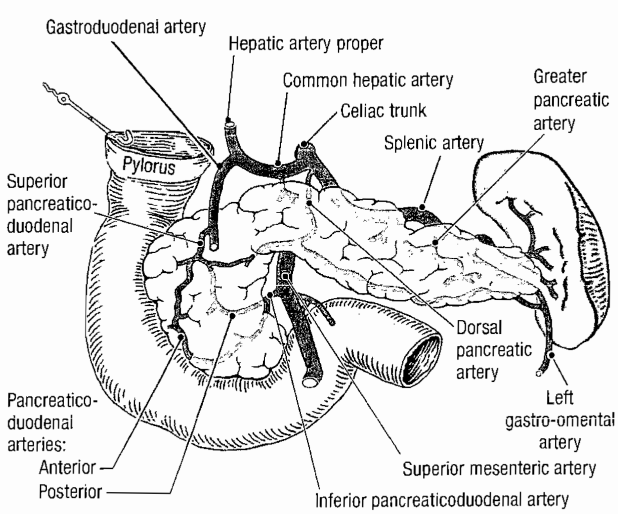


Figure 4.44. Blood supply of the duodenum and pancreas.

   - **Greater pancreatic (pancreatica magna) artery** – enters the pancreas at the junction of the medial two-thirds and lateral one-third of the gland.
8. Follow the splenic artery to the hilum of the spleen and identify the **left gastro-omental artery.** Complete the dissection of the left gastro-omental artery by following it through the greater omentum to its anastomosis with the right gastro-omental artery.
9. The veins of the pancreas correspond to the arteries. They drain into the superior mesenteric and splenic veins and ultimately are tributary to the hepatic portal vein.

HEPATIC PORTAL VEIN [G 152; N 301; R 290; C 201]

Use an illustration to review the hepatic portal venous system. The **superior mesenteric vein** and the **splenic vein** join to form the hepatic portal vein posterior to the neck of the pancreas. The **hepatic portal vein** carries venous blood to the liver from the abdominal portion of the gastrointestinal tract, the spleen, and the pancreas.

1. The **splenic vein** courses posterior to the pancreas, inferior to the splenic artery. Use a probe to dissect posterior to the body of the pancreas and find the splenic vein.
2. Follow the splenic vein to the right, where it is joined by the superior mesenteric vein. This is the origin of the **hepatic portal vein.** Recall that the hepatic portal vein ascends in the hepatoduodenal ligament to the porta hepatis.
3. Return to the field of distribution of the inferior mesenteric vein. Find it and follow it superiorly. The inferior mesenteric vein usually joins the splenic vein, but it may join the superior mesenteric vein, or the junction of the superior mesenteric and splenic veins.
4. Use a textbook or atlas to review the portal–systemic (portal–caval) anastomoses:
   - **Gastroesophageal** – left gastric vein/esophageal veins/azygos vein
   - **Anorectal** – superior rectal vein/middle and inferior rectal veins
   - **Paraumbilical** – paraumbilical veins/superficial epigastric veins
   - **Retroperitoneal** – colic veins/retroperitoneal veins

CLINICAL CORRELATION

Portal Hypertension

The hepatic portal system of veins has no valves. When the hepatic portal vein becomes blocked, blood pressure increases in the hepatic portal system (portal hypertension) and its tributaries become engorged. Portal hypertension causes hemorrhoids, and varicose gastric and esophageal veins. Bleeding from ruptured **gastroesophageal varices** is a dangerous complication of portal hypertension.

After you dissect . . .

Review the relationship of each part of the duodenum to surrounding structures. Review the branches of the celiac trunk and superior mesenteric artery. Use an illustration and the dissected specimen to reconstruct the blood supply to the pancreas and duodenum. Review the formation and field of drainage of the hepatic portal vein. Trace a drop of blood from the small intestine to the inferior vena cava. Use an embryology textbook to review the development of the liver, pancreas, and duodenum.

REMOVAL OF THE GASTROINTESTINAL TRACT

Before you dissect . . .

The order of dissection will be as follows. The arteries to the gastrointestinal tract (celiac trunk, superior mesenteric artery, and inferior mesenteric artery) will be cut close to the aorta. The esophagus and rectum will be cut, using ligatures to prevent spillage of their contents. The gastrointestinal tract will then be removed and reviewed outside of the body. The gastrointestinal tract will be taken to a sink and selected areas will be opened and rinsed to study specializations of the mucosa.

Dissection Instructions

1. Tie two strings 4 cm apart around the superior end of the rectum. Use scissors to cut the rectum *between the strings*. Cut the superior rectal artery.
2. Inferior to the diaphragm, tie one string around the esophagus and cut the esophagus superior to the string. Cut the vagus nerve trunks at the same level.
3. Use scissors to cut the celiac trunk close to the aorta, leaving no stump.
4. Use scissors to cut the superior and inferior mesenteric arteries near the aorta, leaving a 1 cm stump of each.
5. Free the stomach from any peritoneal attachments it may still have to the posterior abdominal wall.
6. Grasp the spleen and gently pull medially. Insert your fingers posterior to the spleen and carefully free the splenic vessels, tail of the pancreas, and body of the pancreas from the posterior abdominal wall.
7. Use scissors to cut the suspensory ligament of the duodenum close to the duodenojejunal junction.
8. Insert your fingers posterior to the duodenum and free it from the posterior abdominal wall.
9. Use scissors to cut the parietal peritoneum lateral to the ascending colon and use your fingers to free the ascending colon from the posterior abdominal wall. Roll the ascending colon toward the midline and use your fingers to loosen its blood vessels from the posterior abdominal wall.
10. Cut the parietal peritoneum lateral to the descending colon and use your fingers to free the descending colon from the posterior abdominal wall. Roll the descending colon toward the midline and use your fingers to loosen its blood vessels from the posterior abdominal wall.
11. The gastrointestinal tract, liver, pancreas, and spleen should now be free of attachments. Remove them from the abdominal cavity. Be careful not to twist or tear the structures in the hepatoduodenal ligament.
12. Arrange the abdominal viscera on the dissecting table in anatomical position and study the parts from the anterior view. Trace the branches of the celiac trunk, superior mesenteric artery, and inferior mesenteric artery to their areas of distribution. Note the differences between the branching pattern of the arteries and the veins. Turn the viscera and repeat the exercise from a posterior view.
13. Carry the viscera to a sink to examine their internal features.
14. Use scissors to open the stomach along its anterior surface. Extend the cut into the first portion of the duodenum. Rinse the mucosa and observe the following features (Fig. 4.45): **[G 121; N 268; R 284; C 199]**
    - **Gastric canal**
    - **Gastric folds (rugae)**
    - **Pyloric antrum**
    - **Pyloric canal**
    - **Pyloric sphincter**
    - **Pyloric orifice**
15. Use scissors to make a longitudinal incision in the anterior wall of the duodenum. In the second part of the duodenum, identify the following (Fig. 4.46): **[G 125; N 271; R 287; C 211]**
    - **Circular folds (plicae circulares)**
    - **Major (greater) duodenal papilla** – an elevation of mucosa on the medial wall of the second part of the duodenum. The major duodenal papilla is the shared opening of the main pancreatic duct and bile duct.
    - **Minor (lesser) duodenal papilla** – the site of drainage of the accessory pancreatic duct. If present, it will be approximately 2 cm superior to the major duodenal papilla.

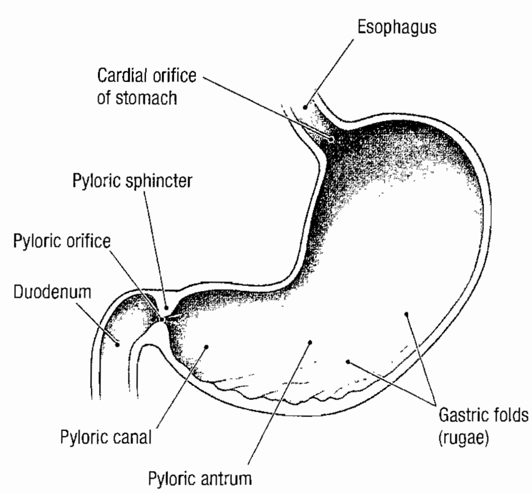


Figure 4.45. Internal features of the stomach.

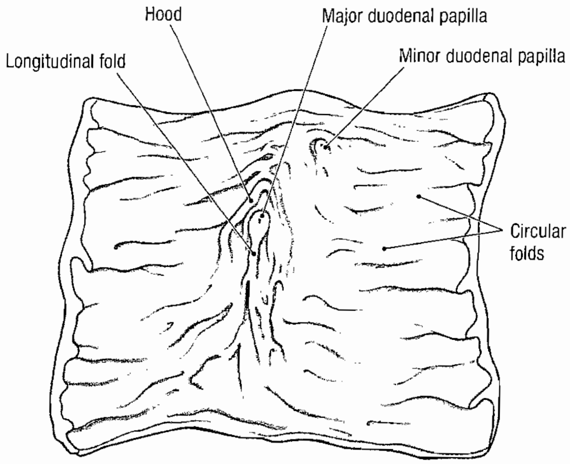


Figure 4.46. Mucosal features in the descending (second) part of the duodenum.

16. Use scissors to make one 5-cm longitudinal incision in the **proximal jejunum** and another in the **distal ileum**. Rinse the mucosa and compare features. Note that the circular folds are larger and closer together in the jejunum (Fig. 4.47). **[G 132; N 272]**
17. Use scissors to make an incision approximately 7.5 cm long in the anterior wall of the **cecum**. Rinse the mucosa and identify the following (Fig. 4.48): **[G 135; N 274; R 298; C 222]**
    - **Ileocecal orifice**
    - **Superior and inferior lips of the ileocecal valve**
    - **Opening of the appendix**

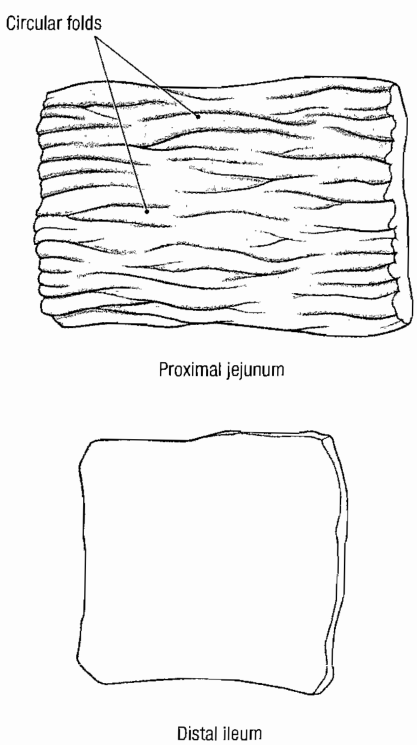


Figure 4.47. Comparison of mucosal features in the proximal jejunum and distal ileum.

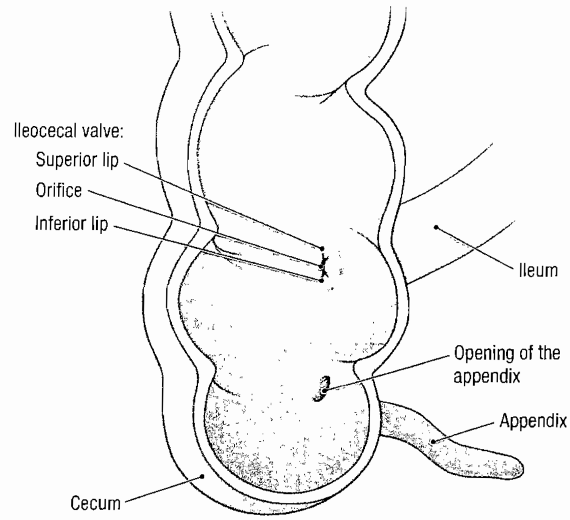


Figure 4.48. Interior of the cecum, from an anterior view.

18. Make an incision approximately 5 cm long in the anterior surface of the transverse colon. Note the **semilunar folds (plicae semilunares)** between adjacent **haustra**. Observe the relative smoothness of the mucosa. **[G 133; N 276; C 224]**
19. The viscera may be stored in a large plastic bag or in the abdominal cavity. Wet these specimens frequently with mold-inhibiting solution.

After you dissect . . .

Review the features of the gastrointestinal mucosa. Compare the quantity and complexity of circular folds in the proximal and distal parts of the small intestine. Compare this arrangement to the mucosal features seen in the stomach and large intestine. Correlate your findings to the function of the organs dissected. Recall the locations of valves in the gastrointestinal tract.

POSTERIOR ABDOMINAL VISCERA

Before you dissect . . .

The posterior abdominal viscera are located in an area that is referred to as the **retroperitoneal space**. The retroperitoneal space is not a real space. It is that part of the body between the parietal peritoneum and the muscles and bones of the posterior abdominal wall (Fig. 4.49). The retroperitoneal space contains the kidneys, ureters, suprarenal glands, aorta, inferior vena cava, and the abdominal portions of the sympathetic trunks. **[G 163; N 332; R 312; C 247]**

The order of dissection will be as follows. The posterior abdominal viscera will be palpated. The kidneys and suprarenal glands will be removed from the renal fascia and studied. The abdominal aorta and the inferior vena cava will be studied. The muscles of the posterior abdominal wall will be studied. The lumbar plexus of nerves will be examined. Finally, the diaphragm will be studied.

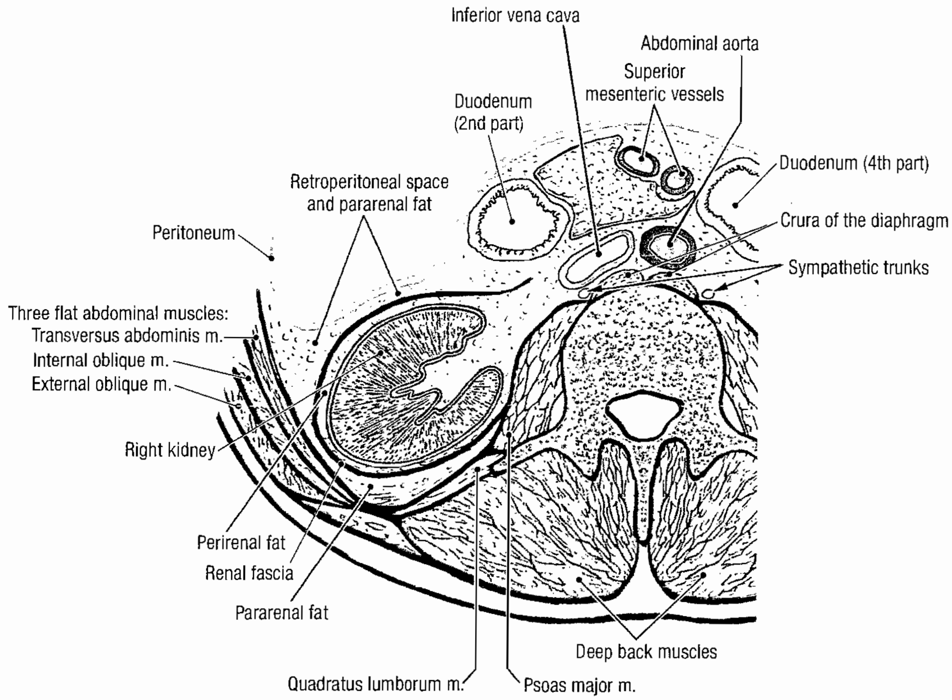


Figure 4.49. Transverse section through the posterior abdominal wall at the level of the kidneys.

Dissection Instructions

1. Use a sponge or paper towels to clean the posterior abdominal wall.
2. Palpate the **kidneys** and the **suprarenal (adrenal) glands**. They lie lateral to the vertebral column at vertebral levels T12 to L3. **[G 155; N 319; R 319; C 228]**
3. Palpate the abdominal aorta.
4. To the right of the abdominal aorta, palpate the inferior vena cava.
5. Remove any remaining parietal peritoneum from the posterior abdominal wall.
6. If you are dissecting a female cadaver, go to step 10.
7. Identify the **testicular artery and vein** at the deep inguinal ring. The testicular artery is quite small and delicate. Follow the testicular vessels superiorly and note that they cross anterior to the ureter. Do not damage the ureter.
8. Observe that the left testicular vein drains into the left renal vein. The right testicular vein drains directly into the inferior vena cava.
9. The **right** and **left testicular arteries** branch directly from the aorta at about vertebral level L2. This origin is inferior to the origin of the renal arteries.

CLINICAL CORRELATION

Testicular Varicocele

Varicocele is a varicose condition of the pampiniform plexus of veins. Varicocele is more common on the left side because the left testicular vein drains into the left renal vein, and the left renal vein is subject to compression where it passes inferior to the superior mesenteric artery.

10. In the **female cadaver**, identify the **ovarian vessels**. Their origin is comparable to that of the testicular vessels in the male. Note that the ovarian vessels cross anterior to the ureter.
11. Inferiorly, the ovarian vessels end in the pelvic cavity. Follow the ovarian vessels inferiorly until they cross the external iliac vessels. Do not follow them into the pelvis at this time.

KIDNEYS [G 155; N 319; R 319; C 228]

The position of the kidneys is well-illustrated on transverse section (Fig. 4.49). The kidneys are well-protected by their position within the body as well as by a cushioning layer of fat.

1. Note that the kidneys lie against the posterior abdominal wall. The anterior aspect of the kidney faces anterolaterally (Fig. 4.49).
2. Use your fingers to separate the **kidney** from the **perirenal fat** and **renal fascia** (Fig. 4.49).
3. Observe that the **superior pole** of the kidney is separated from the suprarenal gland by a thin layer of renal fascia. Carefully insert your fingers between the kidney and the suprarenal gland and separate the two organs. Be careful not to remove the suprarenal gland with the fat.
4. Note the size and shape of the kidney.
5. Identify the **left renal vein**. Use a probe to trace the left renal vein from the left kidney to the inferior vena cava. Observe that it crosses anterior to the renal arteries and aorta.
6. Identify and clean the tributaries of the left renal vein:
   - **Left testicular** (or **ovarian**) **vein**
   - **Left suprarenal vein**

7. Use scissors to cut the left renal vein close to the inferior vena cava. Reflect the left renal vein toward the left. Do not detach the testicular (or ovarian) vein or the left suprarenal vein from the left renal vein.
8. Identify the **left renal artery**, which lies posterior to the left renal vein. Follow the left renal artery to the hilum of the kidney. The renal artery usually divides before it enters the kidney, and accessory renal arteries are common.
9. Observe small branches of the left renal artery to the ureter and left suprarenal gland.
10. Using the left renal artery as a hinge, turn the left kidney toward the right. At the most posterior part of the hilum, identify the **renal pelvis** and its inferior continuation, the **ureter**.
11. Use blunt dissection to follow the ureter inferiorly. Observe that the abdominal part of the ureter passes posterior to the testicular (or ovarian) vessels and crosses the anterior surface of the psoas major muscle. The pelvic part of the ureter will be seen later.
12. Return the left kidney to its correct anatomical position.
13. Clean the relatively short right renal vein. Note that it has no tributaries.
14. Reflect the inferior vena cava inferiorly and slightly toward the right. Identify the **right renal artery**, which lies posterior to the right renal vein and inferior vena cava. Note that the right renal artery is longer than the left renal artery. The right renal pelvis lies posterior to the right renal artery.
15. Follow the right ureter inferiorly and observe its relationship to the right testicular (ovarian) vessels.
16. Use an illustration to review the relationships of the kidneys: **[G 154; N 319; R 306; C 229]**
    - The suprarenal gland is superior to the kidney.
    - Through the peritoneum, the right kidney is in contact with the right colic flexure, the visceral surface of the liver and the second part of the duodenum.
    - Through the peritoneum, the left kidney is in contact with the tail of the pancreas, the left colic flexure, the stomach, and the spleen.
17. Divide the left kidney into anterior and posterior halves by splitting it longitudinally along its lateral border. Open the two halves of the kidney like a book.
18. Identify (Fig. 4.50): **[G 158; N 321; R 314; C 233]**
    - **Renal capsule** – a fibrous capsule which can be stripped off of the surface of the kidney
    - **Renal cortex** – the outer zone of the kidney (approximately one-third of its depth)
    - **Renal medulla** – the inner zone of the kidney consisting of **renal pyramids** and **renal columns** (approximately two-thirds of its depth)
    - **Renal sinus** – the space within the kidney that is occupied by the renal pelvis, calices, vessels, nerves, and fat.
    - **Renal papilla** – the apex of the renal pyramid that projects into a minor calyx
    - **Minor calyx** – a cup-like chamber that is the beginning of the extrarenal duct system. Several minor calyces combine to form a major calyx.

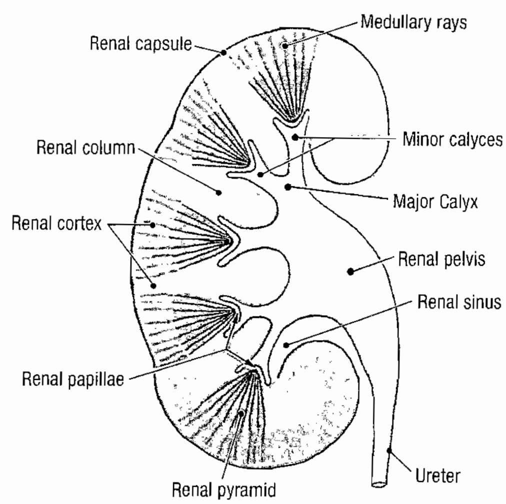


Figure 4.50. Internal features of the kidney in longitudinal section.

- **Major calyx** – two or three per kidney that combine to form the renal pelvis
- **Renal pelvis** – the funnel-like end of the ureter that lies within the renal sinus
- **Ureter** – the muscular duct that carries urine from the kidney to the urinary bladder

CLINICAL CORRELATION

Kidney Stones

Kidney stones (renal calculi) may form in the calyces and renal pelvis. Small kidney stones may spontaneously pass through the ureter into the bladder. Larger kidney stones may lodge at one of three natural constrictions of the ureter: (1) where the renal pelvis joins the ureter; (2) where the ureter crosses the pelvic brim; and (3) at the entrance of the ureter into the urinary bladder.

SUPRARENAL GLANDS [G 155; N 322, 333; R 314; C 230]

The **suprarenal (adrenal) glands** are fragile and easily torn. They are closely related to the superior poles of the kidneys (Fig. 4.51). The suprarenal glands are highly vascularized endocrine glands.

1. Observe that the **right suprarenal gland** is triangular in shape. Part of the right suprarenal gland lies posterior to the inferior vena cava.
2. Observe that the **left suprarenal gland** is semilunar in shape.
3. The suprarenal glands receive multiple arteries (Fig. 4.51). Identify **superior suprarenal arteries** arising

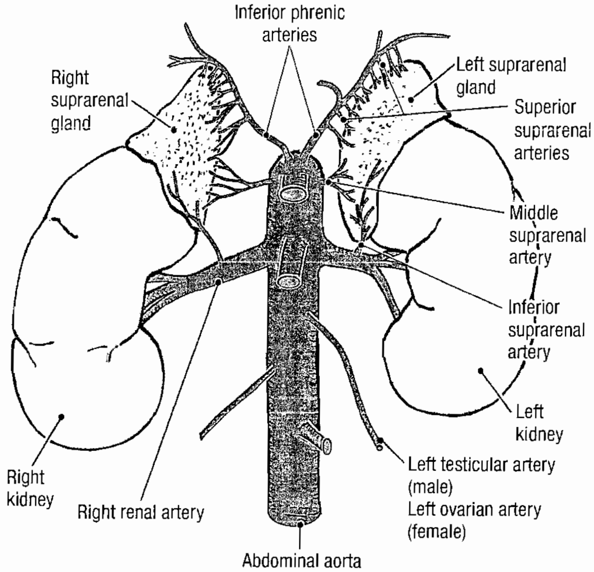


Figure 4.51. Blood supply of the suprarenal glands.

from the **inferior phrenic arteries. Middle suprarenal arteries** arise from the aorta near the celiac trunk. **Inferior suprarenal branches** arise from the renal arteries.

4. Note that the left suprarenal vein empties into the left renal vein. The right suprarenal vein drains directly into the inferior vena cava.
5. The suprarenal glands receive numerous sympathetic nerve fibers.

CLINICAL CORRELATION

Suprarenal Glands

The kidneys and suprarenal glands have different embryonic origins. If the kidney fails to ascend to its normal position during development, the suprarenal gland develops in its normal position lateral to the celiac trunk.

ABDOMINAL AORTA AND INFERIOR VENA CAVA [G 167; N 319; R 319; C 238]

1. Use an illustration to study the abdominal aorta. Observe that the abdominal aorta has three types of branches:
   - **Unpaired arteries to the gastrointestinal tract** (celiac trunk, superior mesenteric and inferior mesenteric arteries)
   - **Paired arteries to the three paired abdominal organs** (suprarenal, renal, and testicular or ovarian arteries)
   - **Paired arteries to the abdominal wall** (inferior phrenic and lumbar arteries)
2. Identify at least one **lumbar artery** (Fig. 4.52). Four pairs of lumbar arteries supply the posterior abdominal wall. Trace one lumbar artery to its origin from the posterior aspect of the abdominal aorta. Note that the lumbar arteries pass deep to the psoas major muscles positioned on either side of the vertebral column.
3. Observe the **bifurcation of the abdominal aorta** at vertebral level L4 (Fig. 4.52). In a thin person, the umbilicus projects superior to the bifurcation of the aorta.
4. Identify the **common iliac arteries**, which arise at the bifurcation of the aorta. The common iliac artery supplies blood to the pelvis and lower limb.
5. Review the **inferior vena cava** and its tributaries. Recall that a segment of the inferior vena cava was removed with the liver. Note that the inferior vena cava has no unpaired visceral tributaries because the hepatic portal system collects blood from the gastrointestinal tract. Review the hepatic portal vein. Recall that the hepatic portal vein drains into the liver, and that the hepatic veins drain into the inferior vena cava.

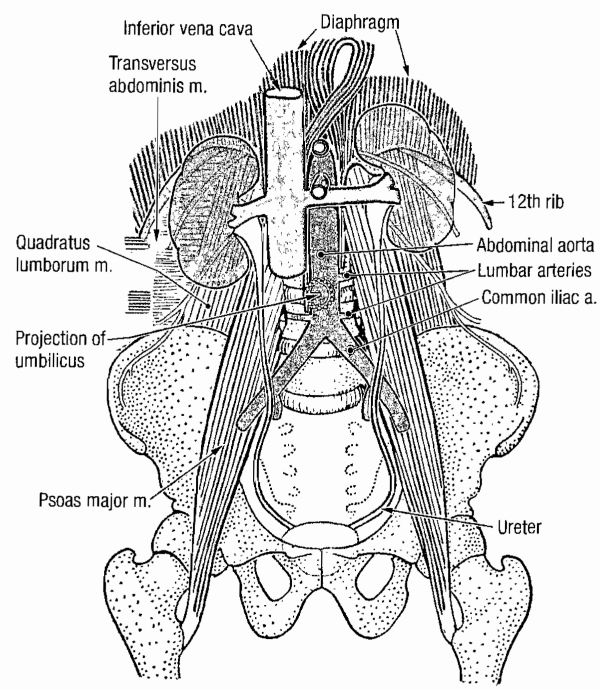


Figure 4.52. Posterior relationships of the kidneys.

After you dissect . . .

Replace the kidneys in their correct anatomical positions. Use an illustration and the dissected specimen to review the relationships of each kidney to surrounding structures. Trace the path taken by a drop of urine from the renal papilla to the ureter. Review the position, relationships, and blood supply of each suprarenal gland. Review the branches of the abdominal aorta.

POSTERIOR ABDOMINAL WALL

Before you dissect . . .

The posterior abdominal wall is composed of the vertebral column, muscles that move the vertebral column, muscles that move the lower limb, and the diaphragm. The nerves that supply the abdominal wall and the lumbar plexus of nerves that supply the lower limb will be dissected with the posterior abdominal wall.

The order of dissection will be as follows. The branches of the lumbar plexus will be studied. Muscles that form the posterior abdominal wall will be dissected. The sympathetic trunk will be studied.

Dissection Instructions

1. Move the kidneys and suprarenal glands toward the midline (do not cut their vessels) and use your hands to remove the remaining fat and the renal fascia from the posterior abdominal wall.
2. Identify the **psoas major muscle** (Fig. 4.53). The proximal attachments of the psoas major muscle are the lumbar vertebrae (bodies, intervertebral discs, and transverse processes). Its distal attachment is the lesser trochanter of the femur. The psoas major muscle is a strong flexor of the thigh and vertebral column. **[G 164; N 255; R 323; C 235]**
3. Look for the **psoas minor muscle.** The psoas minor muscle is absent in approximately 40% of cases and may be present on only one side of the cadaver. The psoas minor muscle has a long flat tendon that passes down the anterior surface of the psoas major muscle to its distal attachment on the pubis.
4. Identify the **iliacus muscle** (Fig. 4.53). The proximal attachment of the iliacus muscle is the iliac fossa. Its distal attachment is on the lesser trochanter of the femur. The iliacus muscle flexes the thigh. The iliacus and psoas major muscles form a functional unit, and together they are called the **iliopsoas muscle**.
5. Identify the **quadratus lumborum muscle** (Fig. 4.53). The proximal attachments of the quadratus lumborum muscle are the twelfth rib and lumbar transverse processes. Its distal attachments are the iliolumbar ligament and iliac crest. The quadratus lumborum muscle flexes the vertebral column laterally and anchors the inferior end of the rib cage during respiration.
6. Review the **transversus abdominis muscle**. The transversus abdominis muscle forms the lateral part of the posterior abdominal wall. The transversus abdominis muscle lies posterior to the quadratus lumborum muscle.
7. Use an illustration and the dissected specimen to study the relationships between the kidneys and the posterior abdominal wall (Fig. 4.52). Verify that the dorsal surface of each kidney is related, through the renal fat and fascia, to the diaphragm, psoas major muscle, quadratus lumborum muscle, and the transversus abdominis muscle. The superior pole of the right kidney is at the level of the twelfth rib. The superior pole of the left kidney is at the level of the eleventh rib.

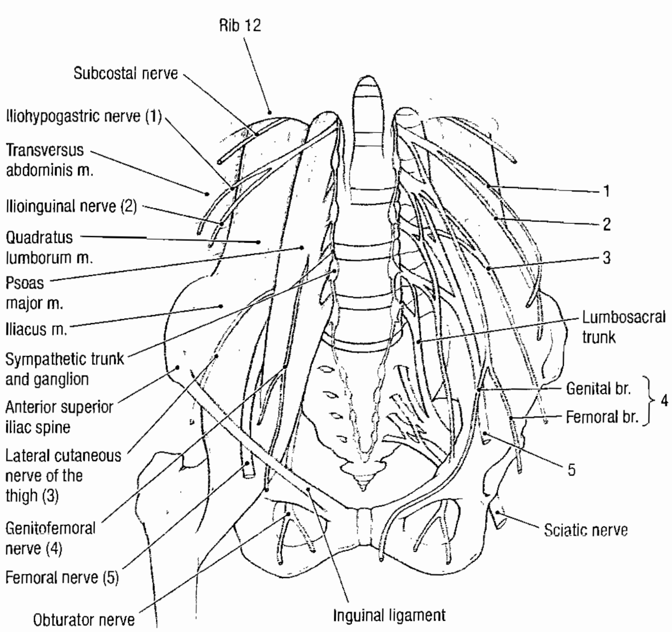


Figure 4.53. Lumbar plexus of nerves.

LUMBAR PLEXUS [G 164, 165; N 259; R 321; C 238]

The nerves of the posterior abdominal wall arise from the ventral primary rami of spinal nerves T12 to L4. The **lumbar plexus** (L1–L4) is formed within the psoas major muscle and its branches can be seen as they emerge from the lateral border of this muscle. The lumbar plexus can be seen only after removal of the psoas major muscle.

Dissect the lumbar plexus on the left side only. Because each branch of the lumbar plexus passes through the psoas major muscle at a different depth, it is necessary to follow each nerve proximally into the psoas major muscle, removing the muscle piece by piece. The nerves of the lumbar plexus are variable in their branching. Use the peripheral relationships of the nerves (their region of distribution or a point of exit from the abdominal cavity) for positive identification.

1. Identify the **genitofemoral nerve.** It is found on the anterior surface of the psoas major muscle (Fig. 4.53). It is the motor nerve to the cremaster muscle (genital part) and supplies a small area of skin inferior and medial to the inguinal ligament (femoral part). The two parts of the genitofemoral nerve divide on the anterior surface of the psoas major muscle superior to the inguinal ligament.
2. Use blunt dissection to remove the fascia from the posterior abdominal wall lateral to the psoas major muscle. The branches of the lumbar plexus are in the extraperitoneal fat and care must be taken to move the dissection instrument parallel to the course of the nerves (Fig. 4.53).
3. To find the **subcostal nerve**, palpate rib 12 and look for the subcostal nerve approximately 1 cm inferior to it.

4. Find the **iliohypogastric** and **ilioinguinal nerves**. They descend steeply across the anterior surface of the quadratus lumborum muscle. Frequently, these two nerves arise from a common trunk and do not separate until they reach the transversus abdominis muscle. To positively identify the ilioinguinal nerve, follow it to the superficial inguinal ring.
5. Identify the **lateral cutaneous nerve of the thigh**. The lateral cutaneous nerve of the thigh passes deep to the inguinal ligament near the anterior superior iliac spine. The lateral cutaneous nerve of the thigh supplies the skin on the lateral aspect of the thigh.
6. Identify the **femoral nerve**. The femoral nerve lies on the lateral side of the psoas major muscle in the groove between the psoas major and iliacus muscles. The femoral nerve innervates these two muscles. The femoral nerve passes deep to the inguinal ligament and provides motor and sensory branches to the anterior thigh.
7. To find the **obturator nerve**, insert your finger on the medial side of the psoas major muscle and move your finger parallel to the muscle, creating a gap between the psoas major muscle and the common iliac vessels. The obturator nerve supplies motor and sensory innervation to the medial thigh.
8. Identify the **lumbosacral trunk**. The lumbosacral trunk is a large nerve that is formed by a contribution from the ventral primary ramus of L4 and all of the ventral primary ramus of L5. The lumbosacral trunk passes into the pelvis to join the sacral plexus.

SYMPATHETIC TRUNK [G 168; N 308; R 322; C 329]

1. Study the location of the **sympathetic trunk** on a transverse section of the abdomen (Fig. 4.49). Note that each sympathetic trunk is found on the vertebral body between the crus of the diaphragm and the psoas major muscle.
2. Identify **lumbar splanchnic nerves** that pass anteriorly from the sympathetic trunk to the aortic autonomic nerve plexus.
3. Identify **rami communicantes** that pass posteriorly from the sympathetic ganglia to lumbar ventral primary rami. Note that each ramus communicans passes between the psoas major muscle and the vertebral body. The gray rami of the lower lumbar region are the longest in the body because the sympathetic trunk crosses the anterolateral surface of the lumbar vertebral bodies.
4. Use an illustration to review the autonomic nerve supply of the abdominal viscera.

After you dissect . . .

Use the dissected specimen to review the proximal and distal attachments, as well as the action of each of the muscles of the posterior abdominal wall. Review the three muscles that form the anterolateral abdominal wall (external oblique, internal oblique, and transversus abdominis). Follow each branch of the lumbar plexus peripherally. Review the region of innervation of each of these nerves. Use an atlas drawing to review the sympathetic trunk.

DIAPHRAGM

Before you dissect . . .

The **diaphragm** forms the roof of the abdominal cavity and the floor of the thoracic cavity (Fig. 4.54). It is the principal muscle of respiration. The diaphragm has a right half and a left half (the **hemidiaphragms**).

The order of dissection will be as follows. The parts of the diaphragm will be identified. The phrenic nerve will be reviewed. The greater splanchnic nerves that pass through the diaphragm will be studied.

Dissection Instructions

1. Use blunt dissection to strip the parietal peritoneum and connective tissue off of the abdominal surface of the diaphragm. **[G 166; N 255; R 273; C 237]**
2. Identify the parts of the diaphragm (Fig. 4.54):
   - **Central tendon** – the aponeurotic center of the diaphragm, which is the distal attachment of all of its muscular parts.
   - **Sternal part** – two small bundles of muscle fibers that attach to the posterior surface of the xiphoid process.
   - **Costal part** – the muscle fibers that attach to the inferior six ribs and their costal cartilages.
   - **Lumbar part** – formed by two crura (right and left).
3. Identify the **right crus**. The proximal attachments of the right crus of the diaphragm are the bodies of vertebrae L1 to L3. The **esophageal hiatus** is an opening in the right crus.
4. Observe the **left crus** (Fig. 4.54). The proximal attachments of the left crus of the diaphragm are the bodies of vertebrae L1 to L2.
5. Identify the **arcuate ligaments (lumbocostal arches)**. The arcuate ligaments are thickenings of fascia that serve as proximal attachments for some of the muscle fibers of the diaphragm. There are two arcuate ligaments on each side of the body:

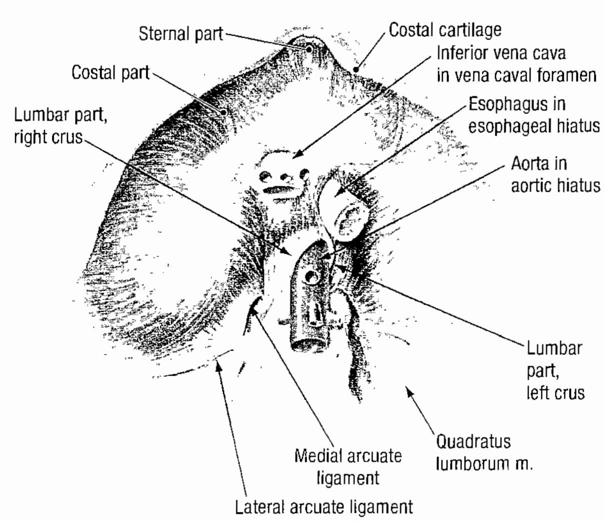


Figure 4.54. Diaphragm.

- **Medial arcuate ligament** – bridges the anterior surface of the psoas major muscle.
- **Lateral arcuate ligament** – bridges the anterior surface of the quadratus lumborum muscle.

6. There are three large openings in the diaphragm (Fig. 4.54). Identify the **vena caval foramen**, which passes through the central tendon (vertebral level T8) and the **esophageal hiatus**, which passes through the right crus (vertebral level T10). The aorta passes through the **aortic hiatus** (vertebral level T12).
7. The **right** and **left phrenic nerves** innervate the diaphragm. Each phrenic nerve provides motor innervation to one half of the diaphragm (one hemidiaphragm). The phrenic nerves supply most of the sensory innervation to the abdominal (parietal peritoneum) and thoracic (parietal pleura) surfaces of the diaphragm. The pleural and peritoneal coverings of the peripheral part of the diaphragm receive sensory fibers from the lower intercostal nerves (T5–T11) and the subcostal nerve.
8. Identify the **greater splanchnic nerve** in the thorax and follow it to the superior surface of the diaphragm. **[G 168; N 259; C 238]**
9. Push a probe through the diaphragm parallel to the greater splanchnic nerve. Note that the greater splanchnic nerve penetrates the crus to enter the abdominal cavity.
10. Observe that the main portion of the greater splanchnic nerve distributes to the celiac ganglion where its sympathetic axons will synapse. The greater splanchnic nerve also innervates the suprarenal gland.
11. Find the **celiac ganglia**. The celiac ganglia are found on the left and right sides of the celiac trunk near its origin from the aorta. The celiac ganglia are the largest of the sympathetic ganglia that are located on the surface of the aorta.
12. Use an illustration or textbook description to review the autonomic nerve supply of the abdomen.

CLINICAL CORRELATION

Diaphragm

The phrenic nerves arise from cervical spinal cord segments (C3–C5). Therefore, pain from the diaphragm is referred to the shoulder region (supraclavicular nerve territory). The diaphragm is paralyzed in cases of high cervical spinal cord injuries, but is spared in low cervical spinal cord injuries. A paralyzed hemidiaphragm cannot contract (descend), so it will appear high in the thorax on a chest X-ray.

After you dissect . . .

Review the attachments of the diaphragm to the skeleton of the thoracic wall. Trace the course of the thoracic aorta as it passes through the aortic hiatus to become the abdominal aorta. Review the course of the esophagus and the vagus nerve trunks through the esophageal hiatus. Recall the position of the heart on the superior surface of the diaphragm and review the course of the inferior vena cava. Study an illustration and observe that the thoracic duct passes through the aortic hiatus and that the splanchnic nerves (greater, lesser, and least) penetrate the crura.